To print higher-resolution math symbols, click the
Hi-Res Fonts for Printing button on the jsMath control panel.

- - -

MathsNet : A-Level+

Steve Blades

Your account expires on: **11 Jul, 2012**

M1 full exam questions

Syllabus: **EdExcel** Questions: **219** Time: **38 hours 47 minutes** Total Marks: **1937**

This paper contains a set of questions followed by the corresponding mark schemes. The time you should spend on each question together with its worth in marks is also given. The content of this paper is based on material from a wide selection of national and international examination boards and organisations.

You are advised to have:
a set of geometrical equipment, pen, HB pencil, eraser. Check if you are allowed a calculator. Some examinations, but not all, allow calculators, including graphical models.

M1 full exam questions

Questions: **219** Time: **38 hours 47 minutes** Total Marks: **1937**

Q1 - ID: 690 *[11 marks, 13 minutes]*

Two helicopters P and Q are moving in the same horizontal plane. They are modelled as particles moving in straight lines with constant speeds. At noon P is at the point with position vector $(25\underset{\sim}{i} + 45\underset{\sim}{j})\,km$ with respect to a fixed origin O. At time t hours after noon the position vector of P is $p\,km$. When $t = 0.5$ the position vector of P is $(35\underset{\sim}{i} - 30\underset{\sim}{j})\,km$. Find

(a) the velocity of P in the form $(a\underset{\sim}{i} + b\underset{\sim}{j})\,kmh^{-1}$,

(b) an expression for p in terms of t.

At noon, Q is at O and at time t hours afterwards the position vector of Q is $q\,km$. The velocity of Q has magnitude $90\,kmh^{-1}$ in the direction of $4\underset{\sim}{i} - 3\underset{\sim}{j}$. Find

(c) an expression for q in terms of t,

(d) the distance, to the nearest km, between P and Q when $t = 3$.

Q2 - ID: 505 *[8 marks, 10 minutes]*

Two ships, P and Q are moving along straight lines with constant velocities. Initially P is at point O and the position vector of Q relative to O is $(4\underset{\sim}{i} + 12\underset{\sim}{j})\,km$, where $\underset{\sim}{i}$ and $\underset{\sim}{j}$ are unit vectors directed due east and due north respectively. The ship P is moving with velocity $(11\underset{\sim}{j})\ kmh^{-1}$ and Q is moving with velocity $(-9\underset{\sim}{i} + 7\underset{\sim}{j})\,kmh^{-1}$.

At time t hours the position vectors of P and Q relative to O are $p\,km$ and $q\,km$ respectively.

(a) Find p and q in terms of t.

(b) Calculate the distance of Q from P when $t = 4$.

(c) Calculate the value of t when Q is due north of P.

Q3 - ID: 7283 *[16 marks, 19 minutes]*

A model boat A moves on a lake with constant velocity $(-i + 6j)\ ms^{-1}$.
At time $t = 0$, A is at the point with position vector $(4i - 12.5j)\ m$. Find
(a) the speed of A,
(b) the direction in which A is moving, giving your answer as a bearing.
At time $t = 0$, a second boat B is at the point with position vector $(-25i + 2j)\ m$.
Given that the velocity of B is $(3i + 4j) ms^{-1}$,
(c) show that A and B will collide at a point P and find the position vector of P.
Given instead that B has speed $10 ms^{-1}$ and moves in the direction of the vector $(3i + 4j)$,
(d) find the distance of B from P when $t = 7$ s.

Q4 - ID: 7297 *[15 marks, 18 minutes]*

A ship S is moving with constant velocity $(-2.5i + 6j)\ kmh^{-1}$.
At time 1200, the position vector of S relative to a fixed origin O is $(12i + 7j)\ km$. Find
(a) the speed of S,
(b) the bearing on which S is moving.
The ship is heading directly towards a submerged rock R. A radar tracking station calculates that, if S continues on the same course with the same speed, it will hit R at the time 1500.
(c) Find the position vector of R.
The tracking station warns the ship's captain of the situation. The captain maintains S on its course with the same speed until the time is 1400. He then changes course so that S moves due north at a constant speed of $4\ kmh^{-1}$. Assuming that S continues to move with this new constant velocity, find
(d) an expression for the position vector of the ship t hours after 1400,
(e) the time when S will be due east of R,
(f) the distance of S from R at the time 1600.

Q5 - ID: 7282 *[14 marks, 17 minutes]*

A boat B is moving with constant velocity. At noon, B is at the point
with position vector $(4i - 5j)\ km$ with respect to a fixed origin O. At 1430 on the
same day, B is at the point with position vector $(9i + 10j)\ km$.
(a) Find the velocity of B, giving your answer in the form $pi + qj$.
At time t hours after noon, the position vector of B is $b\,km$.
(b) Find, in terms of t, an expression for b.
Another boat C is also moving with constant velocity. The position vector of C, $c\,km$,
at time t hours after noon, is given by $c = (-8i + 19j) + t(6i + \lambda j)$, where λ is a constant.
Given that C intercepts B,
(c) find the value of λ,
(d) show that, before C intercepts B, the boats are moving with the same speed.

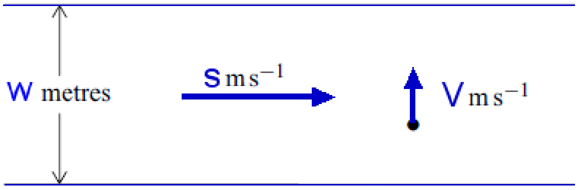
Q6 - ID: 7420

[5 marks, 6 minutes]

An aeroplane flies in air that is moving due east at a speed of $V\ ms^{-1}$.
The velocity of the aeroplane relative to the air is $145\,ms^{-1}$ due north.
The aeroplane actually travels on a bearing of 026°.
(a) Show that V = $70.7\,ms^{-1}$, correct to three significant figures.
(b) Find the magnitude of the resultant velocity of the aeroplane.

Q7 - ID: 7772

[9 marks, 11 minutes]



A girl in a boat is rowing across a river, in which the water is flowing at $s = 0.2\,ms^{-1}$. The velocity of the boat relative to the water is $V = 0.3\,ms^{-1}$ and is perpendicular to the bank, as shown in the diagram.
(a) Find the magnitude of the resultant velocity of the boat.
(b) Find the acute angle between the resultant velocity and the bank.
The width of the river is 17 metres.
(c) Find the time that it takes the boat to cross the river.
(d) Find the total distance travelled by the boat as it crosses the river.

Q8 - ID: 2888

[13 marks, 16 minutes]

A particle P is moving with constant velocity $(-5\underline{i} + 5\underline{j})\ ms^{-1}$. Find

(a) the speed of P,
(b) the direction of motion of P, giving your answer as a bearing.
At time $t = 0$, P is at the point A with position vector $(6\underline{i}-9\underline{j})m$ relative to a fixed origin O.
When $t = 3\,s$, the velocity of P changes and it moves with velocity $(u\underline{i} + v\underline{j})ms^{-1}$, where u and v are constants. After a further $6\,s$, it passes through O and continues to move with velocity $(u\underline{i} + v\underline{j})ms^{-1}$.

(c) Find the values of u and v.
(d) Find the total time taken for P to move from A to a position which is due south of A.

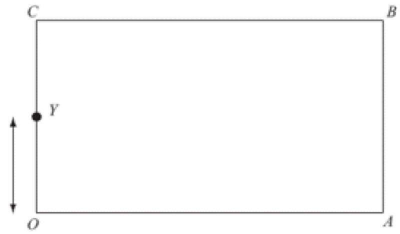
Q9 - ID: 7302 *[4 marks, 5 minutes]*

The velocity of a ship, relative to the water in which it is moving, is $8ms^{-1}$ due north. The water is moving due east with a speed of $U\ ms^{-1}$.
The resultant velocity of the ship has magnitude $9ms^{-1}$.
(a) Find U.
(b) Find the direction of the resultant velocity of the ship.
Give your answer as a bearing to the nearest degree.

Q10 - ID: 7311 *[8 marks, 10 minutes]*

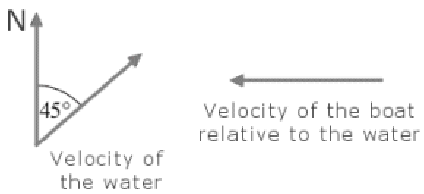
An aeroplane is travelling due north at $193ms^{-1}$ relative to the air.
The air is moving north-west at $59ms^{-1}$.
(a) Find the magnitude of the resultant velocity of the aeroplane.
(b) Find the direction of the resultant velocity, giving your answer as a three-figure bearing to the nearest degree.

Q11 - ID: 6978 *[13 marks, 16 minutes]*



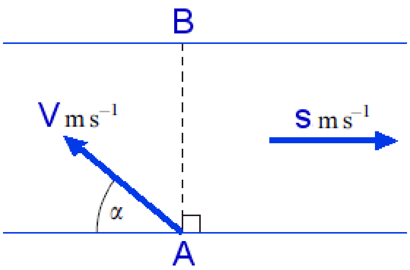
A hiker H is walking with constant velocity $(1.2i - 0.8j)ms^{-1}$.
(a) Find the speed of H.
A horizontal field OABC is rectangular with OA due east and OC due north, as shown.
At twelve noon hiker H is at the point Y with position vector $90j\ m$, relative to the fixed origin O.
(b) Write down the position vector of H at time t seconds after noon.
At noon, another hiker K is at the point with position vector $(7i + 48j)\ m$. Hiker K is moving with constant velocity $(0.75i + 1.9j)\ ms^{-1}$.
(c) Show that, at time t seconds after noon, $\vec{HK} = [(7 - 0.45t)i + (-42 + 2.7t)j]$ metres.
(d) Hence show that the two hikers meet and find the position vector of the point where they meet.

Q12 - ID: 7327 *[8 marks, 10 minutes]*



A boat is travelling in water that is moving north-east at a speed of $3ms^{-1}$.
The velocity of the boat relative to the water is $2ms^{-1}$ due west.
(a) Show that the magnitude of the resultant velocity of the boat is $2.12ms^{-1}$, correct to 3 significant figures.
(b) Find the bearing of the direction the boat is travelling, giving your answer to the nearest degree.

Q13 - ID: 7766 *[6 marks, 7 minutes]*



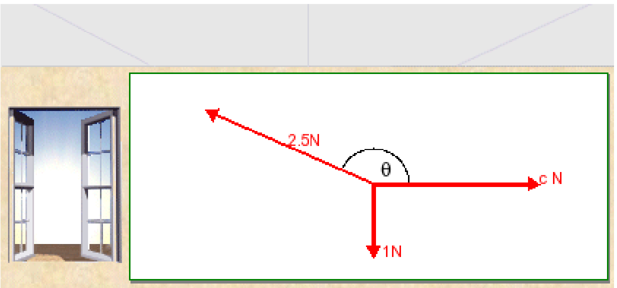
A river has parallel banks which are 15 metres apart. The water in the river flows at $s = 1.1\,ms^{-1}$ parallel to the banks. A boat sets off from one bank at the point A and travels perpendicular to the bank so that it reaches the point B, which is directly opposite the point A. It takes the boat 5 seconds to cross the river. The velocity of the boat relative to the water has magnitude $V\ ms^{-1}$ and is at an angle α to the bank, as shown in the diagram.

(a) Show that the magnitude of the resultant velocity of the boat is $3\,ms^{-1}$.
(b) Find V.
(c) Find α.

Q14 - ID: 7270 *[14 marks, 17 minutes]*

A ship S is moving along a straight line with constant velocity.
At time t hours the position vector of S is s km.
When $t = 0$, $s = 11i - 7j$. When $t = 4$, $s = 23i + 5j$. Find
(a) the speed of S,
(b) the direction in which S is moving, giving your answer as a bearing.
(c) Show that $s = (3t + 11)i + (3t - 7)j$.
A lighthouse L is located at the point with position vector $(20i + 6j)$ km.
When $t = T$, the ship S is 11 km from L.
(d) Find the possible values of T.

Q15 - ID: 481 *[6 marks, 7 minutes]*



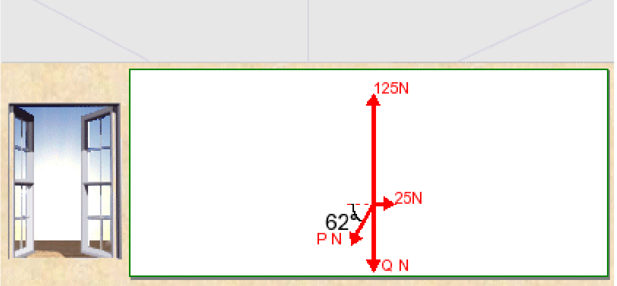
A particle is in equilibrium under the action of three coplanar forces.
The three forces have magnitudes $1\,N$, $2.5\,N$ and $c\,N$.
Calculate
(a) the value to 1 decimal place of θ.
(b) the value to 2 decimal places of c.

Q16 - ID: 3157 *[9 marks, 11 minutes]*

Two forces P and Q act on a particle. The force P has magnitude $13\,N$ and acts due north. The resultant of P and Q is a force of magnitude $16\,N$ acting in a direction with bearing 114°. Find
(a) the magnitude of Q,
(b) the direction of Q, giving your answer as a bearing.

Q17 - ID: 2911

[5 marks, 6 minutes]



The diagram shows four forces in equilibrium.

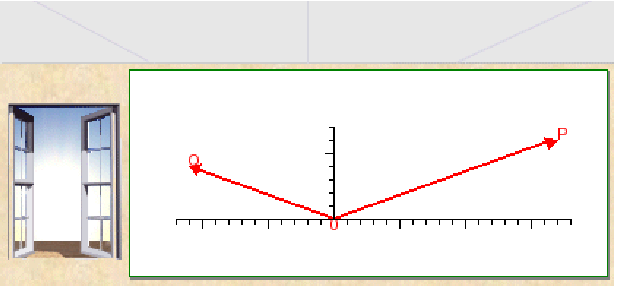
$X = 25, Y = 125, \theta = 62$

(a) Find the value of P.

(b) Hence find the value of Q.

Q18 - ID: 4579

[6 marks, 7 minutes]



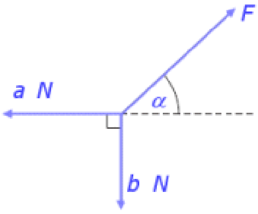
Two horizontal forces P and Q act at the origin O of rectangular coordinates Oxy (see diagram). The components of P in the x- and y-directions are 17 N and 6 N respectively. The components of Q in the x- and y- directions are -11 N and 4 N respectively.

(a) Write down the components, in the x-and y-directions,of the resultant of P and Q.

(b) Hence find the magnitude of this resultant, and the angle the resultant makes with the positive x-axis.

Q19 - ID: 7424

[6 marks, 7 minutes]



The diagram shows three forces which act in the same plane and are in equilibrium, where $a = 6\,N$ and $b = 4\,N$.

(a) Find F

(b) Find α.

Q20 - ID: 2906

[7 marks, 8 minutes]

Force F is $\begin{pmatrix} 5 \\ 1 \\ 4 \end{pmatrix}$ N and force G is $\begin{pmatrix} -8 \\ 2 \\ 3 \end{pmatrix}$ N

(a) Find the resultant of F and G and calculate its magnitude.

(b) Forces F, $2G$ and H act on a particle which is in equilibrium. Find H.

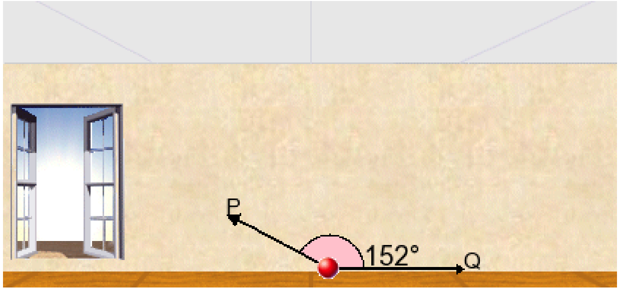
Q21 - ID: 3303

[9 marks, 11 minutes]

Two forces P and Q act on a particle. The force P has magnitude 14 N and the force Q has magnitude X newtons. The angle between P and Q is $\theta = 152°$, as shown. The resultant of P and Q is R. Given that the angle between R and Q is 57°, find

(a) the magnitude of R,

(b) the value of X.


P
152°
Q

Q22 - ID: 4577 *[8 marks, 10 minutes]*

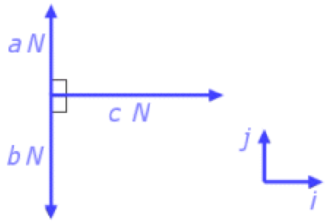
Two horizontal forces P and Q act at a point O and are are
right angles to each other. P has magnitude 14 N and acts along a bearing of 090°.
Q has magnitude 14 newtons and acts along a bearing of 000°.
(a) Calculate the magnitude and bearing of the resultant of P and Q.
(b) A third force, R, is now applied at O. The three forces, P, Q and R are in equilibrium.
State the magnitude of R and give the bearing along which it acts.

Q23 - ID: 5458 *[5 marks, 6 minutes]*

A particle has position vector r, where $r = 5\underline{i} - 7\underline{j}$.

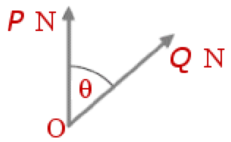
(a) Calculate the magnitude of r and its direction as a bearing.
(b) Write down the vector that has the same direction as r and 6 times its magnitude.

Q24 - ID: 7309 *[6 marks, 7 minutes]*



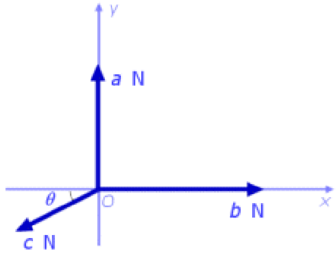
The diagram shows three forces, where $a = 13$, $b = 16$, $c = 6$, and the perpendicula unit vectors i and j, which all lie in the same plane.
(a) Express the resultant of the three forces in terms of i and j.
(b) Find the magnitude of the resultant force.
(c) Find the angle that the resultant force makes with the unit vector i.

Q25 - ID: 7333 *[8 marks, 10 minutes]*



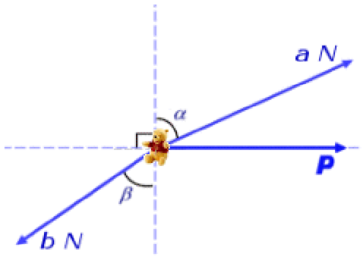
Two horizontal forces act at a point O. One force has magnitude $P = 14\,N$ and acts along bearing 000°.
The other force has magnitude $Q = 16\,N$ and acts along bearing $\theta = 037°$ (as shown).
(a) Show that the magnitude of the resultant of the two forces has magnitude 28.5 ms^{-1}, correct to 3 significant figures.
(b) Find the bearing of the line of action of the resultant.

Q26 - ID: 7394 *[8 marks, 10 minutes]*



Three horizontal forces of magnitudes $a = 9\,N$, $b = 7\,N$ and $c = 10\,N$ act at a point in directions as shown in the diagram. Angle $\theta = 26°$
Find the magnitude of the resultant of these three forces and the angle between the resultant and the $7\,N$ force.

Q27 - ID: 7408 *[11 marks, 13 minutes]*

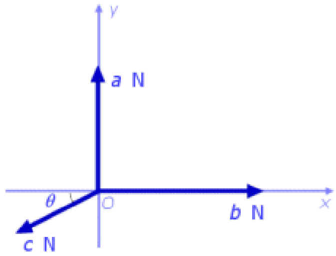


Three children each apply a force to a soft toy. The forces are of magnitude $a = 4\,N$, $b = 7\,N$ and P newtons and act as shown, where $\alpha = 62°$ and $\beta = 46°$.
The resultant of these 3 forces acts in a direction at 45° below the line of action of P.
(a) Show that $P = 4.49$
(b) Find the magnitude of the resultant.

Q28 - ID: 6972 *[6 marks, 7 minutes]*

A particle is acted upon by two forces F_1 and F_2 ,
given by $F_1 = (i - 3j)\ N$, $F_2 = (pi + 5pj)\ N$, where p is a positive constant.
(a) Find the angle between F_2 and j
The resultant of F_1 and F_2 is R. Given that R is parallel to i,
(b) find the value of p.

Q29 - ID: 7341 *[8 marks, 10 minutes]*



Three horizontal forces act at the point O. One force has magnitude $a = 3\,N$ and acts along the positive y-axis. The second force has magnitude $b = 6\,N$ and acts along the positive x-axis. The third force has magnitude $c = 3\,N$ and acts at an angle of 27° below the negative x-axis (see diagram).
(a) Find the magnitudes of the components of the $3\,N$ force along the two axes.
(b) Calculate the magnitude of the resultant of the three forces. Calculate also the angle the resultant makes with the positive x-axis.

Q30 - ID: 1931 *[7 marks, 8 minutes]*

A car starts from rest at a point O and moves in a straight line. The car moves with constant acceleration 6 m s^{-2} until it passes the point A when it is moving with speed 10 m s^{-1}. It then moves with constant acceleration 5 m s^{-2} for 8 s until it reaches the point B . Find
(a) the speed of the car at B,
(b) the distance OB.

Q31 - ID: 1935 *[7 marks, 8 minutes]*

An aircraft moves along a straight horizontal runway with constant acceleration. It passes a point A on the runway with speed 14 m/s. It then passes the point B on the runway with speed 40 m/s. The distance from A to B is 110m.
(a) Find the acceleration of the aircraft.
(b) Find the time taken by the aircraft in moving from A to B.
(c) Find the speed of the aircraft when it passes the point mid-way between A and B.

Q32 - ID: 1936 *[8 marks, 10 minutes]*

A racing car moves along a straight horizontal road with constant acceleration. It passes the point O with speed 13 m/s. It passes the point A 4s later with speed 66 m/s.
(a) Show that the acceleration of the car is 13.25 ms^{-2}.
(b) Find the distance OA.
The point B is the mid-point of OA.
(c) Find the speed of the car when it passes point B.

Q33 - ID: 1937 *[6 marks, 7 minutes]*

A car moves with constant acceleration along a straight horizontal road. The car passes the point A with speed $3ms^{-1}$ and 6 s later it passes the point B, where AB = 54 m.
(a) Find the acceleration of the car.
When the car passes the point C, it has speed 33 ms^{-1}.
(b) Find the distance AC.

Q34 - ID: 1938 *[5 marks, 6 minutes]*

A car accelerates uniformly from rest to a speed of 15 ms^{-1} in T seconds. The car then travels at a constant speed of $15ms^{-1}$ for $5T$ seconds and finally decelerates uniformly to rest in a further $50s$.
The total distance travelled by the car is $1200m$. Find
(a) the value of T
(b) The initial acceleration of the car.

Q35 - ID: 722 *[6 marks, 7 minutes]*

In taking off, an aircraft moves on a straight runway AB of length $1.6km$. The aircraft moves from A with initial speed $1ms^{-1}$. It moves with constant acceleration and $14s$ later it leaves the runway at C with speed $75ms^{-1}$. Find
(a) the acceleration of the aircraft,
(b) the distance BC.

Q36 - ID: 789 *[10 marks, 12 minutes]*

A train moves along a straight track with constant acceleration. Three telegraph poles are set at equal intervals beside the track at points A, B and C, where $AB = 50m$ and $BC = 50m$.
The front of the train passes A with speed $20ms^{-1}$, and $2s$ later it passes B. Find
(a) the acceleration of the train,
(b) the speed of the front of the train when it passes C,
(c) the time that elapses from the instant the front of the train passes B to the instant it passes C.

Q37 - ID: 7421 *[12 marks, 14 minutes]*

A boat is initially at the origin, heading due east at $7\,ms^{-1}$. It then experiences a constant acceleration of $(-0.5i + 0.3j)ms^{-2}$. The unit vectors i and j are directed east and north respectively.
(a) State the initial velocity of the boat as a vector.
(b) Find an expression for the velocity of the boat t seconds after it has started to accelerate.
(c) Find the value of t when the boat is travelling due north.
(d) Find the bearing of the boat from the origin when the boat is travelling due north.

Q38 - ID: 7769 *[6 marks, 7 minutes]*

A motorcycle accelerates uniformly along a straight horizontal road so that, when it has travelled 20 metres, its velocity has increased from $11\,ms^{-1}$ to $16\,ms^{-1}$.
(a) Find the acceleration of the motorcycle.
(b) Find the time that it takes for the motorcycle to travel this distance.

Q39 - ID: 7774 *[12 marks, 14 minutes]*

A particle is initially at the origin, where it has velocity $(6i - 3j)\,ms^{-1}$. It moves with a constant acceleration $a\,ms^{-2}$ for 5 seconds to the point with position vector $80i$ metres.
(a) Show that $a = (4i + 1.2j)\ ms^{-2}$.
(b) Find the position vector of the particle 4 seconds after it has left the origin.
(c) Find the position vector of the particle when it is travelling parallel to the unit vector i.

Q40 - ID: 5461 *[7 marks, 8 minutes]*

Particles P and Q move in the same straight line. Particle P starts from rest and has a constant acceleration of $0.3\,ms^{-2}$ towards Q.
Particle Q starts $69\,m$ from P at the same time and has a constant speed of $5.4\,ms^{-1}$ away from P.
(a) Write down expressions for the distances travelled by P and Q t seconds after the start of the motion.
(b) How much time does it take P to catch up Q and how far does P travel in this time?

Q41 - ID: 7307 *[14 marks, 17 minutes]*

A Jet Ski is at the origin and is travelling due north at $4\,ms^{-1}$ when it begins to accelerate uniformly. After accelerating for 16 seconds, it is travelling due east at $2\,ms^{-1}$. The unit vectors i and j are directed east and north respectively.
(a) Show that the acceleration of the Jet Ski is $(0.125i - 0.25j)\,ms^{-2}$.
(b) Find the position vector of the Jet Ski at the end of the 40 second period.
The Jet Ski is travelling southeast t seconds after it leaves the origin.
(c) Find t.
(d) Find the velocity of the Jet Ski at this time.

Q42 - ID: 7313 *[13 marks, 16 minutes]*

The unit vectors i and j are directed east and north respectively.
A helicopter moves horizontally with a constant acceleration of $(-0.2i + 0.7j)\,ms^{-2}$.
At time $t = 0$, the helicopter is at the origin and has velocity $(10i)\ ms^{-1}$.
(a) Write down an expression for the velocity of the helicopter at time t seconds.
(b) Find the time when the helicopter is travelling due north.
(c) Find an expression for the position vector of the helicopter at time t seconds.
When $t = 100$,
(d) show that the helicopter is due north of the origin;
(e) find the speed of the helicopter.

Q43 - ID: 5039 *[5 marks, 6 minutes]*

A particle P moves with constant acceleration $(4\underline{i} - 4\underline{j})\ ms^{-2}$.
At time $t = 0$, P has speed $u\,ms^{-1}$. At time $t = 2\,s$, P has velocity $(-5\underline{i} + 4\underline{j})\,ms^{-1}$. Find the value of u.

Q44 - ID: 6971 *[7 marks, 8 minutes]*

Three posts P, Q and R, are fixed in that order at the side of a straight horizontal road. The distance from P to Q is $48\,m$ and the distance from Q to R is $120\,m$.
A car is moving along the road with constant acceleration $a\,ms^{-2}$. The speed of the car, as it passes P, is $u\,ms^{-1}$. The car passes Q 2 seconds after passing P, and the car passes R 4 seconds after passing Q.
Find the values of u and a

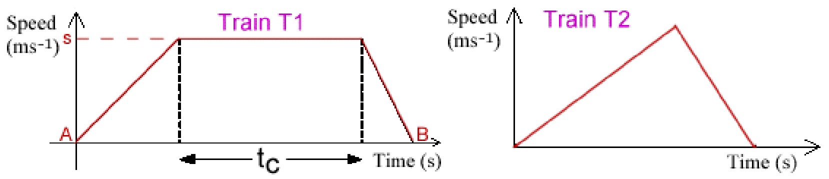
Q45 - ID: 7352 *[8 marks, 10 minutes]*

A particle is travelling in a straight line. Its velocity $v\,ms^{-1}$ at time t seconds is given by $v = 4 + 2t$ for $0 \lesssim t \lesssim 3$.
(a) Write down the initial velocity of the particle and find the acceleration for $0 \lesssim t \lesssim 3$.
(b) Write down the velocity of the particle when $t = 3$. Find the distance travelled in the first 3 seconds.
For $3 \lesssim t \lesssim 14$, the acceleration of the particle is $3\,ms^{-2}$.
(c) Find the total distance travelled by the particle during the 14 seconds.

Q46 - ID: 7767 *[12 marks, 14 minutes]*

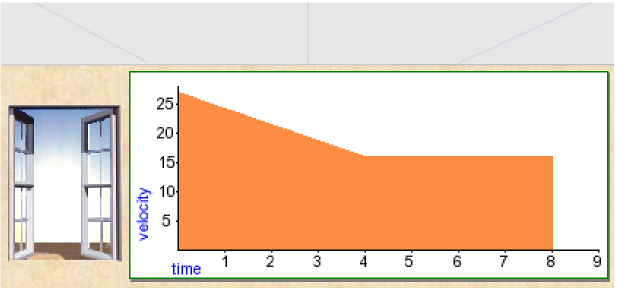
A particle moves on a smooth horizontal plane. It is initially at the point A, with position vector $(11i + 6j)\,m$, and has velocity $(-3i + 2j)\ ms^{-1}$.
The particle moves with a constant acceleration of $(0.2i + 0.3j)\ ms^{-2}$ for 10 seconds until it reaches the point B.
The unit vectors i and j are directed east and north respectively.
(a) Find the velocity of the particle at the point B.
(b) Find the velocity of the particle when it is travelling due north.
(c) Find the position vector of the point B.
(d) Find the average velocity of the particle as it moves from A to B.

Q47 - ID: 1933 *[9 marks, 11 minutes]*



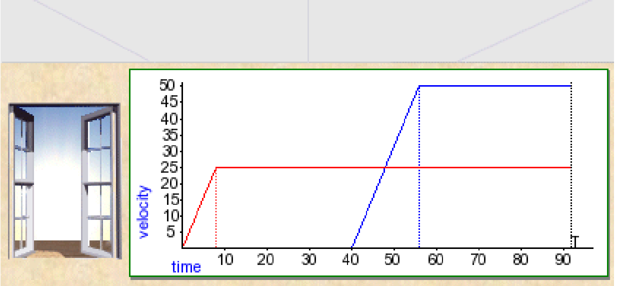
A train, T1, moves from rest at Station A with constant acceleration $3ms^{-2}$ until it reaches a speed of s=42 m/s.
It maintains this constant speed for t_c = 80s before the brakes are applied, which produce constant retardation 3 ms^{-2}.
The train T1 comes to rest at station B, as shown above left.
(a) Show that the distance between A and B is 3948 m.
(b) A second train T2 takes 190 s to move form rest at A to rest at B. Above right shows the speed-time graph illustrating this journey. Explain briefly one way in which T1 's journey differs from T2 's journey.
(c) Find the greatest speed, in m/s, attained by T2 during its journey.

Q48 - ID: 1934 *[9 marks, 11 minutes]*



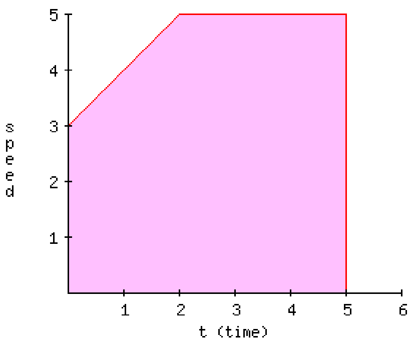
A car of mass 1060kg moves along a straight horizontal road. In order to obey a speed restriction, the brakes of the car are applied for 4 s, reducing the cars speed from 27 ms^{-1} to 16 ms^{-1}. The brakes are then released and the car continues at a constant speed of 16 ms^{-1} for a further 4 s. The diagram above shows a speed-time graph of the car during this 8 s interval. The graph consists of two straight line segments.
(a) Find the total distance travelled.
(b) Explain briefly how the speed-time graph shows that, when the brakes are applied, the car experiences a constant retarding force.
(c) Find the magnitude of this retarding force.

Q49 - ID: 448 *[9 marks, 11 minutes]*



Two trains, A and B, run on parallel straight tracks. Initially both are at rest in a station and level with each other. At time $t = 0$, A starts to move. It moves with constant acceleration for 8*s* up to a speed of $25ms^{-1}$, and then moves at a constant speed of $25ms^{-1}$. Train B starts to move in the same direction as A when $t = 40s$. It accelerates with the same initial acceleration as A, up to a speed of $50ms^{-1}$. It then moves at a constant speed of $50ms^{-1}$. Train B overtakes A after both trains have reached their maximum speed. Train B overtakes A when $t = T$.
Find the value of T.

Q50 - ID: 7285 *[6 marks, 7 minutes]*



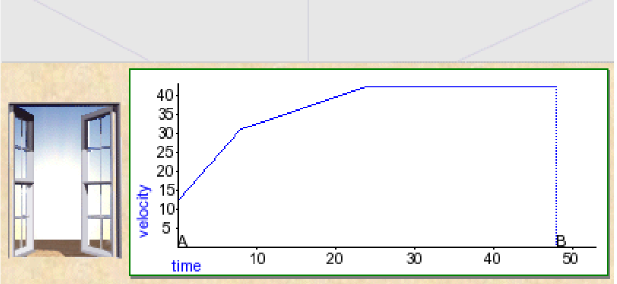
The diagram shows the speed-time graph of a cyclist moving on a straight road over a 5 s period. The sections of the graph from $t = 0$ to $t = 2$, and from $t = 2$ to $t = 5$ are straight lines. The section from $t = 2$ to $t = 5$ is parallel to the t-axis.
State what can be deduced about the motion of the cyclist from the fact that

(a) the graph from $t = 0$ to $t = 2$ is a straight line,

(b) the graph from $t = 2$ to $t = 5$ is parallel to the t-axis.

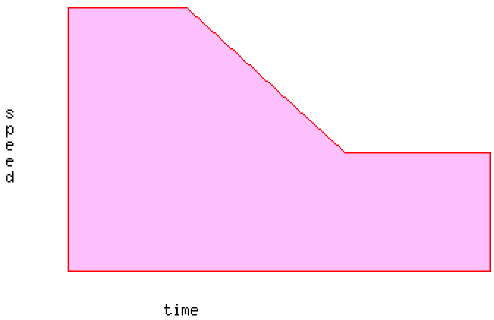
(c) Find the distance travelled by the cyclist during this 5 s period.

Q51 - ID: 2912 *[5 marks, 6 minutes]*



A car passes a point A travelling at $12\,ms^{-1}$. Its motion over the next 48 seconds is modelled as follows. The car's speed increases uniformly from $12\,ms^{-1}$ to $31\,ms^{-1}$ over the first 8 seconds.
Its speed then increases uniformly to $42\,ms^{-1}$ over the next 16 seconds.
The car then maintains this speed for a further 24 seconds at which time it reaches the point B.
(a) Calculate the distance from A to B.
(b) When it reaches the point B, the car is brought uniformly to rest in T seconds.
The total distance from A is now $1911\,m$. Calculate the value of T.

Q52 - ID: 7277 *[8 marks, 10 minutes]*

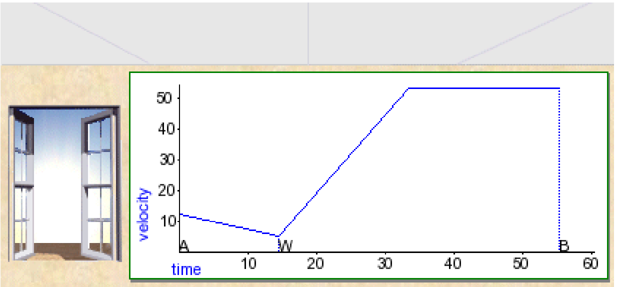


A car is moving along a straight horizontal road. At time $t = 0$, the car passes a point A with speed $20ms^{-1}$. The car moves with constant speed $20ms^{-1}$ until $t = 9$ s. The car then decelerates uniformly for 12 s. At time $t = 21$ s, the speed of the car is $V\ ms^{-1}$ and this speed is maintained until the car reaches the point B at time $t = 32$ s.
Given that AB = $453\,m$, find
(a) the value of V,
(b) the deceleration of the car between $t = 9$ s and $t = 21$ s.

Q53 - ID: 7423 *[10 marks, 12 minutes]*

A lift rises vertically from rest with a constant acceleration. After 5 seconds, it is moving upwards with a velocity of $2ms^{-1}$. It then moves with a constant velocity for 6 seconds. The lift then slows down uniformly, coming to rest after it has been moving for a total of 13 seconds.
(a) Sketch a velocity–time graph for the motion of the lift.
(b) Calculate the total distance travelled by the lift.
(c) The lift is raised by a single vertical cable. The mass of the lift is 350 kg. Find the maximum tension in the cable during this motion.

Q54 - ID: 2885 *[8 marks, 10 minutes]*

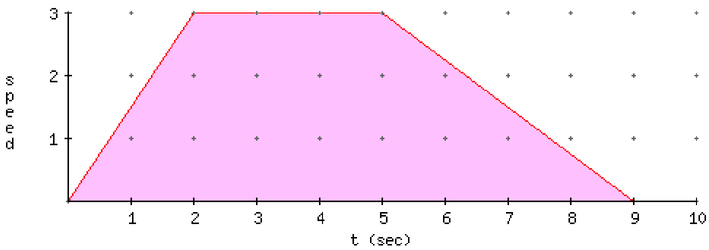


A car moves along a horizontal straight road, passing two points A and B.
At A the speed of the car is 12 ms^{-1}. When the driver passes A, he sees a warning sign W ahead of him, 123 m away. He immediately applies the brakes and the car decelerates with uniform deceleration, reaching W with speed 5 ms^{-1}. At W, the driver sees that the road is clear. He then immediately accelerates the car with uniform acceleration for 19 s to reach a speed of $Vms^{-1} (V > 12)$. He then maintains the car at a constant speed of Vms^{-1}. Moving at this constant speed, the car passes B after a further 25 s.
(a) Find the time taken for the car to move from A to B.
The distance from A to B is 2 km.
(b) Find the value of V.

Q55 - ID: 2904 *[6 marks, 7 minutes]*

A cyclist starts from rest and takes 7 seconds to accelerate at a constant rate up to a speed of 18 ms^{-1}. After travelling at this speed for 20 seconds, the cyclist then decelerates to rest at a constant rate over the next 5 seconds.
(a) Sketch a velocity - time graph for the motion.
(b) Calculate the distance travelled by the cyclist.

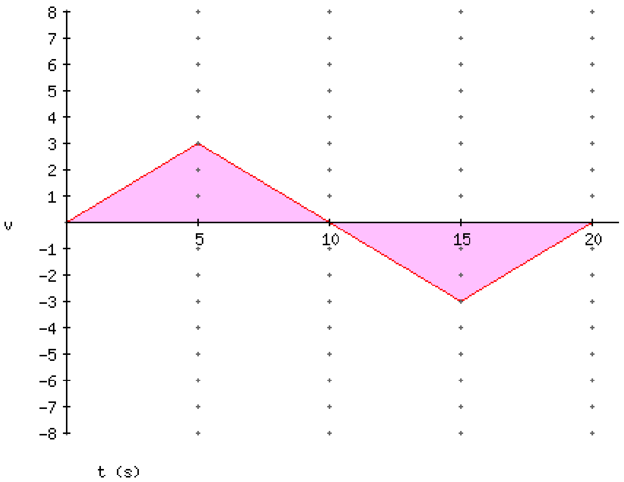
Q56 - ID: 7308 *[7 marks, 8 minutes]*



The diagram shows a velocity–time graph for a lift.
(a) Find the distance travelled by the lift.
(b) Find the acceleration of the lift during the first 2 seconds of the motion.
The lift is raised by a single vertical cable. The mass of the lift is 400 *kg*.
(c) Find the tension in the cable during the first 2 seconds of the motion.

Q57 - ID: 7331

[8 marks, 10 minutes]



An athlete runs from point A to point B and then back to point A.
The diagram shows the (t, v) graph for the motion of the athelete.
The graph consists of three straight line segments.
(a) Calculate the initial acceleration of the athlete.
(b) Calculate the total distance the athlete runs.
(c) Calculate the velocity of the athlete when $t = 18$.

Q58 - ID: 7387

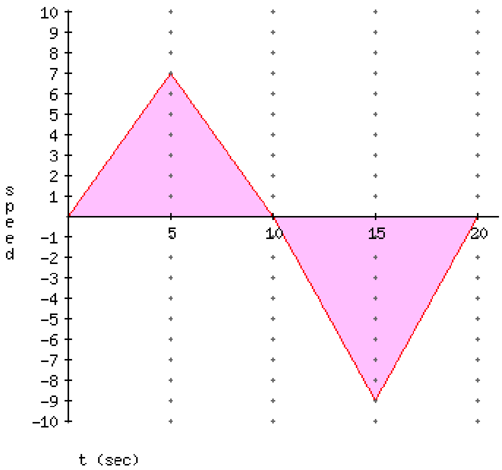
[6 marks, 7 minutes]

A train is travelling along a straight horizontal track. As the train passes point A, its speed is $18\,ms^{-1}$ and immediately after passing point A, it decelerates uniformly for $6\,s$ until its speed is $13\,ms^{-1}$. The train then accelerates at $0.5\,ms^{-2}$ until it reaches a speed of $23\,ms^{-1}$. The train maintains the speed of $23\,ms^{-1}$ for the next $32\,s$ at which time it passes the point B.
(a) Find the time taken for the acceleration.
(b) Draw a sketch of the velocity - time graph for the journey between A and B.

Q59 - ID: 7402 *[14 marks, 17 minutes]*

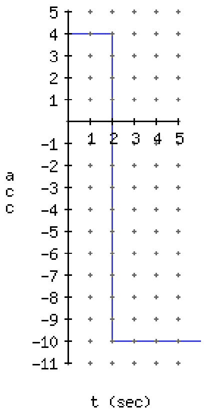
A and B are two bus stops on a straight horizontal road. A bus passes A travelling towards B at a constant velocity of 17 ms^{-1}. The bus continues at this velocity for T seconds. It then decelerates at a constant rate for the next 11 s until it comes to rest at B.
(a) Sketch a velocity–time graph for the motion of the bus.
(b) Find the deceleration of the bus.
(c) Find, in terms of T, the distance travelled by the bus.
5 s after the bus passes A, a car leaves A and travels towards B. The car moves from rest with a constant acceleration of $\frac{6}{4}\, ms^{-2}$ The car and bus reach B at the same time.
(d) Find the distance between A and B.

Q60 - ID: 7315 *[10 marks, 12 minutes]*



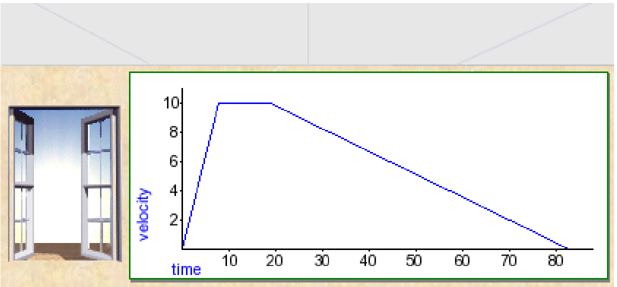
The graph shows how the velocity of a particle varies during a 20 second period as it moves forwards and then backwards along a straight line.
(a) State the times at which the velocity of the particle is zero.
(b) Show that the particle moves a distance of 35 m during the first 10 seconds of its motion.
(c) Find the total distance travelled by the particle during the 20 seconds.
(d) Find the distance of the particle from its initial position after the 20 - second period.

Q61 - ID: 7353 *[4 marks, 5 minutes]*



The graph shows an acceleration-time graph modelling the motion of a particle.
At $t = 0$ the particle has a velocity of $6ms^{-1}$ in the positive direction.
(a) Find the velocity of the particle when $t = 2$.
(b) At what time is the particle travelling in the negative direction with a speed of $6ms^{-1}$?

Q62 - ID: 7269 *[5 marks, 6 minutes]*



An athlete runs along a straight road. She starts from rest and moves with constant acceleration for 8 seconds, reaching a speed of $10ms^{-1}$. This speed is then maintained for T seconds. She then decelerates at a constant rate until she stops.
She has run a total of $470\,m$ in 83 seconds.
Calculate the value of T.

Q63 - ID: 1939 *[8 marks, 10 minutes]*

A competitor makes a dive from a highboard into a diving pool. She leaves the board vertically with a speed of 2 m/s upwards. When she leaves the board, she is 6 m above the surface of the pool. The diver is modelled as a particle moving vertically under gravity alone and it is assumed that she does not hit the springboard as she descends. Find
(a) her speed when she reaches the surface of the pool,
(b) the time taken to reach the surface of the pool.
(c) State two physical characteristics which have been ignored in the model.

Q64 - ID: 827 *[6 marks, 7 minutes]*

A stone is thrown vertically upwards with speed $11 ms^{-1}$ from a point h metres above the ground.
The stone hits the ground $3s$ later. Find
(a) the value of h,
(b) the speed of the stone as it hits the ground.

Q65 - ID: 738 *[10 marks, 12 minutes]*

A ball is projected vertically upwards with speed $17\, ms^{-1}$ from a point A, which is $1.3\, m$ above the ground. After projection, the ball moves freely under gravity until it reaches the ground. Modelling the ball as a particle, find
(a) the greatest height above A reached by the ball,
(b) the speed of the ball as it reaches the ground.
(c) the time between the instant when the ball is projected from A and the instant when the ball reaches the ground.

Q66 - ID: 7419 *[5 marks, 6 minutes]*

A hot air balloon is at rest on the ground. When the balloon is released, it rises to a height of 317 metres in 66 seconds. The balloon moves under the action of its weight and a vertical lift force. Assume that the balloon has a constant acceleration during this motion.
(a) Show that the acceleration of the balloon is $0.146\, ms^{-2}$.
(b) Find the speed of the balloon when it reaches a height of 317 metres.

Q67 - ID: 2884 *[8 marks, 10 minutes]*

A firework rocket starts from rest at ground level and moves vertically.
In the first $5\, s$ of its motion, the rocket rises $22\, m$. The rocket is modelled as a particle moving with constant acceleration $a ms^{-2}$. Find
(a) the value of a,
(b) the speed of the rocket $5\, s$ after it has left the ground.
After $5\, s$, the rocket burns out. The motion of the rocket is now modelled as that of a particlemoving freely under gravity.
(c) Find the height of the rocket above the ground $8\, s$ after it has left the ground.

Q68 - ID: 3301 *[7 marks, 8 minutes]*

At time $t = 0$, a particle is projected vertically upwards with speed $u\,ms^{-1}$ from a point 11.6 m above the ground. At time T seconds, the particle hits the ground with speed 18.4 ms^{-1}. Find
(a) the value of u,
(b) the value of T.

Q69 - ID: 7388 *[8 marks, 10 minutes]*

A stone is projected vertically upwards from a point A at the top of a tower 73 m high. It reaches the highest point of its path after 2.8 s.
(a) Show that the speed of projection of the stone is 27.44 ms^{-1}.
(b) Find the height of the stone above A 5 s after projection.
(c) Calculate the speed of the stone when it reaches the ground.

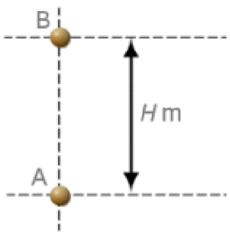
Q70 - ID: 5040 *[3 marks, 4 minutes]*

A small ball is projected vertically upwards from ground level with speed $u\,ms^{-1}$. The ball takes 24 s to return to ground level. The maximum height of the ball above the ground during the first 24 s is 705.6 m. Find the value of u.

Q71 - ID: 7346 *[4 marks, 5 minutes]*

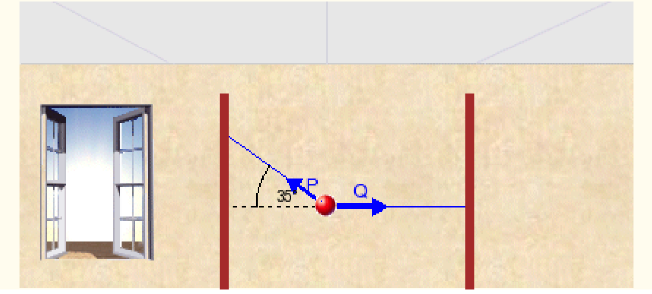
Small parcels are being loaded onto a trolley. Initially the parcels are 3.1 m above the trolley.
A parcel is released from rest and falls vertically onto the trolley. Calculate
(a) the time taken for a parcel to fall onto the trolley,
(b) the speed of a parcel when it strikes the trolley.

Q72 - ID: 7357 *[7 marks, 8 minutes]*



Small stones A and B are initially in the positions shown with B a height H m directly above A. At the instant when B is released from rest, A is projected vertically upwards with a speed of 39.2 ms^{-1}. Air resistance may be neglected. The stones collide T seconds after they begin to move. At this instant they have the same speed, V ms^{-1}, and A is still rising. By considering when the speed of A upwards is the same as the speed of B downwards, or otherwise, show that $T = 2$ and find the values of V and H.

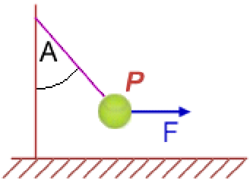
Q73 - ID: 1887 *[6 marks, 7 minutes]*



A particle of weight 40*N* is held in equilibrium by two light inextensible strings. One string is horizontal. The other string is inclined at an angle of 35° to the horizontal, as shown. The tension in the horizontal string is *Q* newtons and the tension in the other string is *P* newtons.
Find

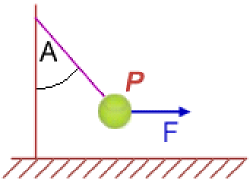
(a) the value of *P*,
(b) The value of *Q*.

Q74 - ID: 3052 *[6 marks, 7 minutes]*



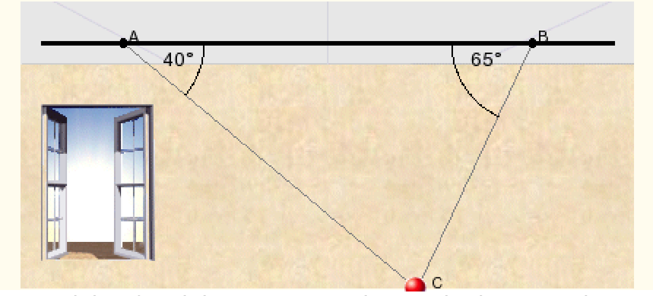
A tennis ball P is attached to one end of a light inextensible string, the other end of the string being attached to a the top of a fixed vertical pole. A girl applies a horizontal force, *F*, of magnitude 70 *N* to P , and P is in equilibrium under gravity with the string making an angle of A=60° with the pole, as shown above.
By modelling the ball as a particle find, to 3 significant figures,
(a) the tension, *T*, in the string.
(b) the weight, *W*, of P.

Q75 - ID: 1910 *[6 marks, 7 minutes]*



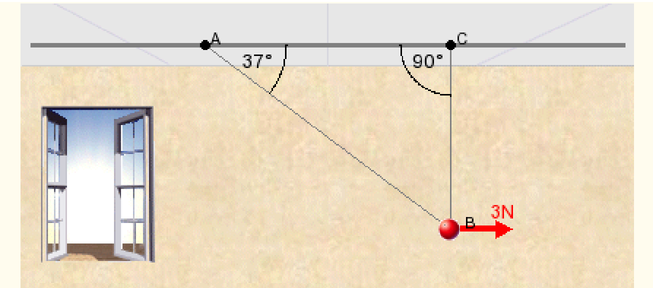
A particle P of weight 6 N is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point. A horizontal force of magnitude F newtons is applied to P. The particle P is in equilibrium under gravity with the string making an angle A =50 degrees with the vertical, as shown above. Find, to 3 significant figures,
(a) the tension, T, in the string.
(b) the value of F.

Q76 - ID: 1913 *[6 marks, 7 minutes]*



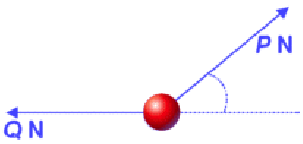
A particle of weight W newtons is attached at C to the ends of two light inextensible strings AC and BC. The other ends of the strings are attached to two fixed points A and B on a horizontal ceiling. The particle hangs in equilibrium with AC and BC inclined to the horizontal at 40° and 65°
degrees respectively. Given that the tension in the string AC is 70 N, calculate
(a) the tension in BC, to 3 significant figures,
(b) the value of W.

Q77 - ID: 608 *[7 marks, 8 minutes]*



A smooth bead *B* is threaded on a light inextensible string. The ends of the string are attached to two fixed points *A* and *C* on the same horizontal level. The bead is held in equilibrium by a horizontal force of magnitude 3*N* acting parallel to *AC*. The bead is vertically below *C* and $\angle BAC = 37$. Find
(a) the tension in the string,
(b) the weight of the bead.

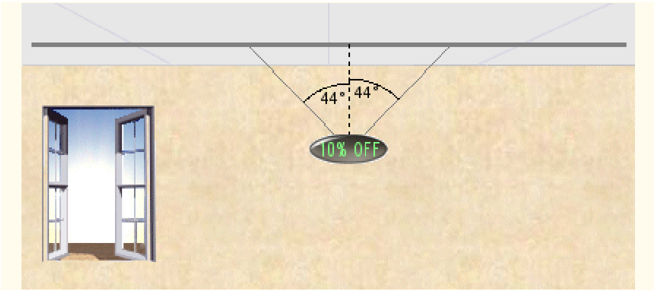
Q78 - ID: 812 *[6 marks, 7 minutes]*



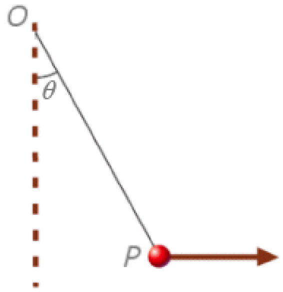
A particle of weight 19*N* is held in equilibrium by two light inextensible strings. One string is horizontal. The other string is inclined at an angle of 21° to the horizontal, as shown. The tension in the horizontal string is *Q* newtons and the tension in the other string is *P* newtons. Find
(a) the value of *P*,
(b) The value of *Q*.

Q79 - ID: 2957 *[10 marks, 12 minutes]*

A sign, of mass 2 *kg*, is suspended from the ceiling of a supermarket by two light strings. It hangs in equilibrium with each string making an angle of $\theta = 44°$ to the vertical. Model the sign as a particle.
(a) By resolving forces horizontally, show that the tension is the same in each string.
(b) Find the tension in each string.
(c) If the tension in a string exceeds 45 *N*, the string will break. Find the mass of the heaviest sign that could be suspended as shown.

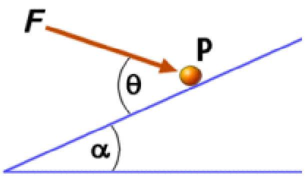

44°
44°
10% OFF

Q80 - ID: 7276 *[7 marks, 8 minutes]*



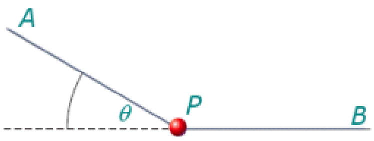
A particle P is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point O. A horizontal force of magnitude 11 N is applied to P.
The particle P is in equilibrium with the string taut and OP making an angle of 20°
with the downward vertical, as shown. Find
(a) the tension in the string,
(b) the weight of P.

Q81 - ID: 2886 *[11 marks, 13 minutes]*



A particle P of mass 6 kg lies on the surface of a smooth plane.
The plane is inclined at an angle of $\alpha = 20°$ to the horizontal. The particle is held in equilibrium by a force of magnitude 55 N, acting at an angle θ to the plane, as showı
The force acts in a vertical plane through a line of greatest slope of the plane.
(a) Show that $\cos\theta = 0.37$
(b) Find the normal reaction between P and the plane.
The direction of the force of magnitude 55 N is now changed. It is now applied horizontally to P so that P moves up the plane. The force again acts in a vertical pla
through a line of greatest slope of the plane.
(c) Find the initial acceleration of P.

Q82 - ID: 7303 *[5 marks, 6 minutes]*



A particle, of mass 3 kg, is suspended in equilibrium by two light strings, AP and BP .
The string AP makes an angle of $\theta = 34°$ to the horizontal and the other string, BP,
is horizontal, as shown.
(a) Show that the tension in the string AP is 78.4 N.
(b) Find the tension in the horizontal string BP.

Q83 - ID: 7350 *[17 marks, 20 minutes]*

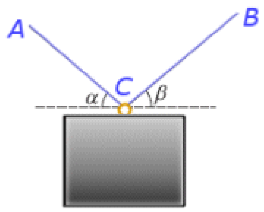


Diagram 1

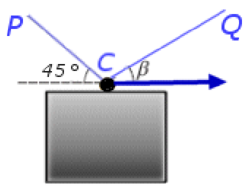
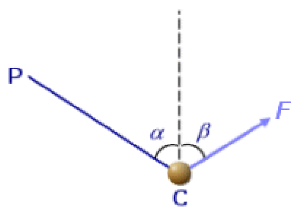


Diagram 2

A box of mass 11 *kg* is supported by a continuous light string ACB, that is fixed at A and B and passes through a smooth ring at C, as shown in Diagram 1.
The box is in equilibrium and the tension in the string section AC is 64 *N*.
(a) What information in the question indicates that the tension in the string section CB is also 64 *N*?
(b) Show that the string sections AC and CB are equally inclined (so that $\alpha = \beta$).
(c) Calculate the angle of the string sections AC and CB to the horizontal.
In a different situation, the same box is supported by two separate light strings PC and CQ which are tied to the box at C. There is a horizontal force of 11 *N* acting at C, angle $\alpha = 45°$ and angle $\beta = 22°$, as shown in Diagram 2.
The box is in equilibrium.
(d) Calculate the tensions in the two strings.

Q84 - ID: 7404 *[6 marks, 7 minutes]*



One end of a light inextensible string is attached to a fixed point P.
The other end of the string is attached to a conker C, mass *m kg*.
The conker is held in equilibrium by a force *F* newtons inclined at $\beta = 62°$ to the vertical as shown. The string is inclined at $\alpha = 42°$ to the vertical. The tension in the string is 0.3 *N*.
(a) Find *F*.
(b) Find *m*.

Q85 - ID: 5484 *[14 marks, 17 minutes]*

Two forces, $(5i - 7j)$ N and $(pi + qj)$ N, act on a particle P of mass m kg.
The resultant of the two forces is R. Given that R acts in a direction which is parallel to the vector $(i - 4j)$,
(a) find the angle between R and the vector j,
(b) show that $4p + q + 13 = 0$.
(c) Given also that $q = 3$ and that P moves with an acceleration of magnitude $11\sqrt{5}ms^{-2}$, find the value of m.

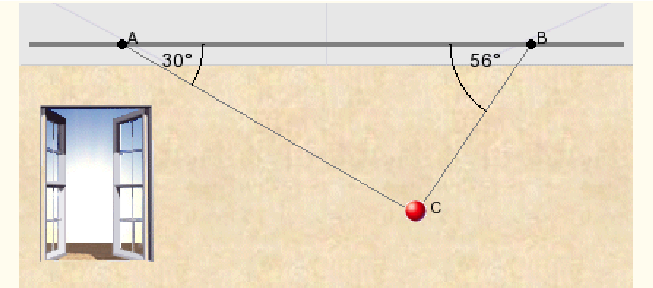
Q86 - ID: 7354 *[6 marks, 7 minutes]*

The resultant of the force $\begin{pmatrix} -8 \\ 12 \end{pmatrix}$ N and the force F gives an object of mass $7\,kg$ an acceleration of $\begin{pmatrix} 4 \\ 4 \end{pmatrix} ms^{-2}$.

(a) Calculate F.

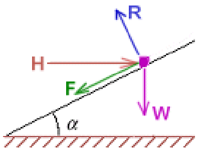
(b) Calculate the angle between F and the vector $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$

Q87 - ID: 7271 *[8 marks, 10 minutes]*



A particle of mass m kg is attached at C to two light inextensible strings AC and BC. The other ends of the strings are attached to two fixed points A and B on a horizontal ceiling. The particle hangs in equilibrium with AC and BC inclined to the horizontal at 30° and 56° degrees respectively.
Given that the tension in the string AC is 49 N, calculate
(a) the tension in BC, to 3 significant figures,
(b) the value of m.

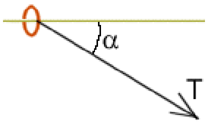
Q88 - ID: 1888 *[9 marks, 11 minutes]*



A small parcel of mass W=4kg is held in equilibrium on a rough plane by the action of a horizontal force of magnitude H=45 N acting in a vertical plane through a line of greatest slope. The plane is inclined at an angle of α = 15 degrees to the horizontal, as shown above. The parcel is modelled as a particle. The parcel is on the point of moving up the slope.
(a) Find the normal reaction, R, on the parcel.
(b) Find the coefficient of friction between the parcel and the plane.

Q89 - ID: 1890

[8 marks, 10 minutes]



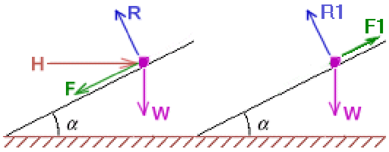
A ring of mass 0.8 kg is threaded on a fixed, rough horizontal curtain pole. A light inextensible string is attached to the ring. The string and the pole lie in the same vertical plane. The ring is pulled downwards by the string which makes an angle α to the horizontal, where $\tan\alpha = \frac{2}{6}$, as shown above.

The tension, T, in the string is 2 N.

Find the coefficient of friction between the ring and the pole.

Q90 - ID: 1909

[12 marks, 14 minutes]



A box of mass W=6kg lies on a rough plane inclined at an angle of α = 40 degrees to the horizontal. The box is held in equilibrium by means of a horizontal force H newtons. The line of action of the force is in the same vertical plane as a line of greatest slope of the plane. The coefficient of friction between the box and the plane is 0.7. The box is modelled as a particle.

Given that the box is in limiting equilibrium and on the point of moving up the plane (as in diagram 1), find

(a) the normal reaction exerted on the box by the plane.

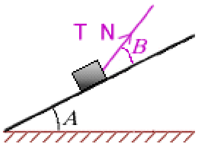
(b) the value of H.

The horizontal force is removed (diagram 2).

(c) Show that the box will now start to move down the plane.

Q91 - ID: 1911

[10 marks, 12 minutes]

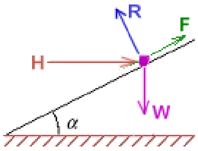


A box of mass 1.6 kg is placed on a plane which is inclined at an angle of A = 33 degrees to the horizontal. The coefficient of friction betwen the box and the plane is $\frac{1}{3}$.The box is kept in equilibrium by a light string which lies in a vertical plane containing a line of greatest slope of the plane. The string makes an angle of B = 17 degrees with the plane. The box is in limiting equilibrium and is about to move up the plane. The tension in the string is T newtons. The box is modelled as a particle.

Find the value of T.

Q92 - ID: 1912

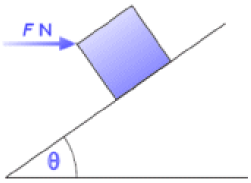
[8 marks, 10 minutes]



A parcel of mass W=7kg lies on a rough plane inclined at an angle of α degrees to the horizontal, where $\tan\alpha = \frac{3}{4}$
The parcel is held in equilibrium by means of a horizontal force H = 20 Ns. The force acts in a vertical plane through a line of greatest slope of the plane. The parcel is on the point of sliding down the plane.
Find the coefficient of friction between the parcel and the plane.

Q93 - ID: 7284

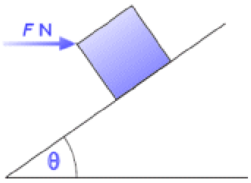
[14 marks, 17 minutes]



A parcel of weight 13 N lies on a rough plane inclined at an angle of $\theta = 25°$ to the horizontal. A horizontal force of magnitude F newtons acts on the parcel, as shown. The parcel is in equilibrium and on the point of slipping up the plane. The normal reaction of the plane on the parcel is 21 N. The coefficient of friction between the parcel and the plane is μ. Find
(a) the value of F,
(b) the value of μ.
The horizontal force is removed.
(c) Determine whether or not the parcel moves.

Q94 - ID: 2915

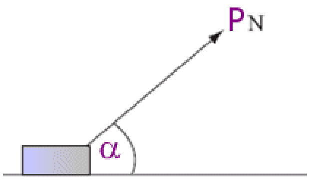
[4 marks, 5 minutes]



A block of weight 103 N is on a rough plane that is inclined at $\theta = 38°$ to the horizontal. The block is in equilibrium with a horizontal force, F, of 33 N acting on it, as shown above.
Calculate the frictional force acting on the block.

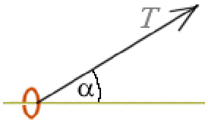
Q95 - ID: 7273

[9 marks, 11 minutes]



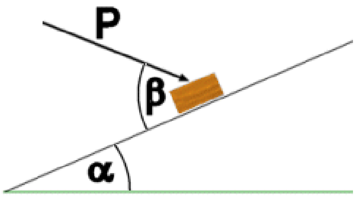
A box of mass 22 kg is being pulled along rough horizontal ground at a constant speed using a rope. The rope makes an angle of $\alpha = 18°$ with the ground, as shown.
The coefficient of friction between the box and the ground is 0.2. The box is modelled as a particle and the rope as a light, inextensible string. The tension in the rope is P newtons.
Find the value of P.

Q96 - ID: 7280 *[10 marks, 12 minutes]*



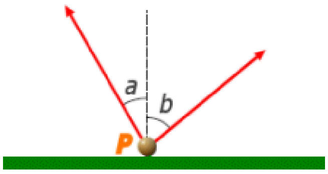
A ring of mass 0.25 kg is threaded on a fixed, rough horizontal rod.
The ring is pulled upwards by a light string which makes an
angle α = 42° with the horizontal, as shown. The string and the rod
are in the same vertical plane. The tension in the string is T = 1.4 N and
the coefficient of friction between the ring and the rod is μ.
is pulled downwards by the string which makes an angle α to
Given that the ring is in limiting equilibrium, find
(a) the normal reaction between the ring and the rod,
(b) the value of μ.

Q97 - ID: 3305 *[11 marks, 13 minutes]*



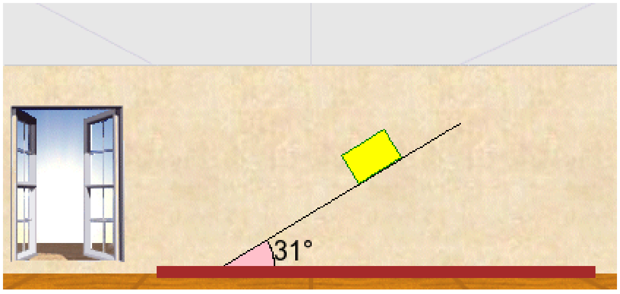
A package of mass 6 kg lies on a rough plane inclined
at α = 29° to the horizontal. The package is held in equilibrium by a force
of magnitude P = 47 N acting at an angle of β = 48° to the plane, as shown.
The force is acting in a vertical plane through a line of greatest slope
of the plane. The package is in equilibrium on the point of moving up
the plane. The package is modelled as a particle. Find
(a) the magnitude of the normal reaction of the plane on the package,
(b) the coefficient of friction between the plane and the package.

Q98 - ID: 7334 *[8 marks, 10 minutes]*



A particle P of weight 27 N rests on a horizontal plane. The particle is attached to
light strings making angles of a = 27° and b = 53° to the upward vertical, as shown.
The tension in each string is 13 N and the particle is in limiting equilibrium.
(a) Find the magnitude and direction of the frictional force on P.
(b) Find the coefficient of friction between P and the plane.

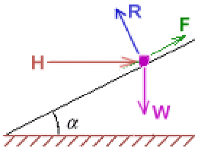
Q99 - ID: 7397 *[7 marks, 8 minutes]*



A box of mass 3.98 kg rests in equilibrium on a rough plane inclined
at 31° to the horizontal as shown. The box is just about to slip
down the plane. Model the box as a particle.
(a) Find the normal reaction between the plane and the box.
(b) Find the coefficient of friction between the plane and the box.

Q100 - ID: 5714

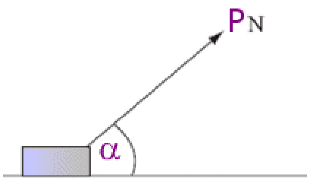
[11 marks, 13 minutes]



A small package of mass $W = 1.3\,kg$ is held in equilibrium on a rough plane by a horizontal force.
The plane is inclined at angle α to the horizontal, where $\tan\alpha = \frac{3}{4}$
The force acts in a vertical plane containing a line of greatest slope and has magnitude H newtons, as shown.
The coefficient of friction between the package and the plane is 0.7 and the package is modelled as a particle. The package is in equilibrium and on the point of slipping down the plane.
All the forces acting on the package are shown.
a) Find the magnitude of the normal reaction R between the package and the plane.
b) Find the value of H.

Q101 - ID: 6975

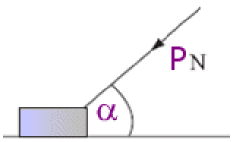
[9 marks, 11 minutes]



A small box of mass $10\,kg$ rests on a rough horizontal plane.
The coefficient of friction between the box and the plane is 0.3 .
A force of magnitude P newtons is applied to the box at $\alpha = 57°$ to the horizontal, as shown in the diagram. The box is on the point of sliding along the plane. Find the value of P, giving your answer to 2 significant figures.

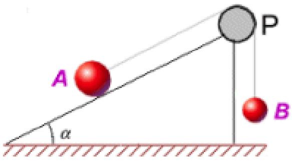
Q102 - ID: 7342

[8 marks, 10 minutes]



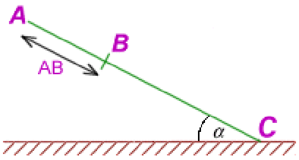
A block of mass $3\,kg$ is placed on a horizontal surface.
A force of $P = 20$ newtons is applied to the box at an angle of $\alpha = 30°$ to the horizontal, as shown in the diagram.
(a) Given that the surface is smooth, calculate the acceleration of the block.
(b) Given instead that the block is in limiting equilibrium, calculate the coefficient of friction between the block and the surface.

Q103 - ID: 1906 *[13 marks, 16 minutes]*



A particle, A, mass 3m, rests on a rough plane inclined at an angle α to the horizontal, where $\tan\alpha = \frac{3}{4}$. The particle is attached to one end of a light inextensible string which lies in a line of greatest slope of the plane and passes over a small light smooth pulley P fixed at the top of the plane. The other end of the string is attached to a particle B of mass 9m , and B hangs freely below P , as shown above. The particles are released from rest with the string taut. The particle B moves down with acceleration of magnitude $\frac{1}{2}g$.
Find
(a) the tension, T, in the string.
(b) the coefficient of friction between A and the plane

Q104 - ID: 1907 *[10 marks, 12 minutes]*



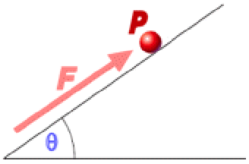
A suitcase of mass 11 kg slides down a ramp which is inclined at an angle of α = 22 degrees to the horizontal. The suitcase is modelled as a particle and the ramp as a rough plane. The top of the plane is A. The bottom of the plane is C and AC is the line of greatest slope. The point B is on AC with AB = 5 m. The suitcase leaves A with a speed of is 10 m/s and passes B with a speed of 7 m/s. Find
(a) the deceleration of the suitcase,
(b) the coefficient of friction between the suitcase and the ramp.
The suitcase reaches the bottom of the ramp.
(c) Find the greatest possible length of AC.

Q105 - ID: 1908 *[10 marks, 12 minutes]*

A particle P of mass 2 kg is projected up a line of greatest slope inclined at an angle of α = 35 degrees to the horizontal. The coefficient of friction between P and the plane is 0.5. The initial speed of P is 6 m/s. Find
(a) the frictional force acting on P as it moves up the plane,
(b) the distance moved by P up the plane before P comes to instantaneous rest.

Q106 - ID: 7288

[11 marks, 13 minutes]



A particle P of mass 0.4 *kg* is on a rough plane inclined at an angle θ to the horizontal, where $\tan\theta = \frac{3}{4}$. The particle is held at rest on the plane by the action of a force of magnitude 4 *N* acting up the plane in a direction parallel to a line of greatest slope of the plane, as shown. The particle is on the point of slipping up the plane.

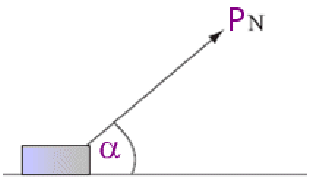
(a) Find the coefficient of friction between P and the plane.

The force of magnitude 4 *N* is removed.

(b) Find the acceleration of P down the plane.

Q107 - ID: 374

[14 marks, 17 minutes]



A box of mass 26 *kg* is being pulled along rough horizontal ground at a constant speed using a rope. The rope makes an angle of $\alpha = 25°$ with the ground. The coefficient of friction between the box and the ground is 0.2.

The box is modelled as a particle and the rope as a light inextensible string. The tension in the rope is P newtons.

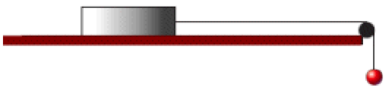
(a) Find the value of P.

The tension in the rope is now increased to 170*N*.

(b) Find the acceleration of the box.

Q108 - ID: 7305

[11 marks, 13 minutes]



A block, of mass 10 *kg*, is placed on a rough horizontal surface.

It is attached, by a light inextensible string that passes over a smooth peg, to a particle of mass 7 *kg*, which hangs freely, as shown in the diagram.

The coefficient of friction between the block and the surface is 0.1.

The block and particle are released from rest and move with the string taut.

(a) Find the magnitude of the friction force acting on the block.

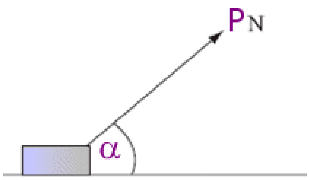
(b) Show that the acceleration of the system is 3.459 ms^{-2}.

(c) The block is travelling at 1.9 ms^{-1} when it reaches the peg.

Find the distance that the block has travelled when it reaches the peg.

Q109 - ID: 7329

[16 marks, 19 minutes]



A block of weight 15.2 N is at rest on a horizontal floor
A force of magnitude 4.6 N is applied to the block.
(a) The block is in limiting equilibrium when the 4.6 N force is applied horizontally. Show that the coefficient of friction is $\frac{23}{76}$.
When the force of 4.6 N is applied at angle of α = 32° above the horizontal, as shown, the block moves across the floor.
(b) Calculate the vertical component of the contact force between the floor and the block, and the magnitude of the frictional force.
(c) Calculate the acceleration of the block.
(d) Calculate the magnitude of the frictional force acting on the block when the 4.6 N force acts at 32° to the upward vertical, justifying your answer fully.

Q110 - ID: 7392

[11 marks, 13 minutes]

An object, of mass 5 kg, moves on a slope inclined at an angle α to the horizontal, where $\sin\alpha = \frac{5}{13}$. The coefficient of friction between the object and the slope is $\frac{1}{6}$.
(a) The object is sliding freely down a line of greatest slope. Find the magnitude of the acceleration of the object.
(b) The object is being pulled up the slope at a constant speed by means of a rope parallel to a line of greatest slope. Find the tension in the rope.

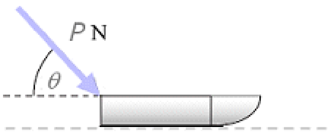
Q111 - ID: 6974

[9 marks, 11 minutes]

A small brick of mass 0.5 kg is placed on a rough plane which is inclined to the horizontal at an angle θ, where $\tan\theta = \frac{4}{3}$, and released from rest. The coefficient of friction between the brick and the plane is $\frac{1}{6}$. Find the acceleration of the brick.

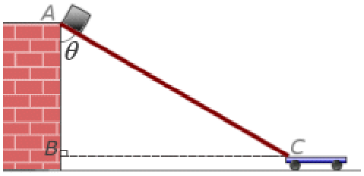
Q112 - ID: 7321

[8 marks, 10 minutes]



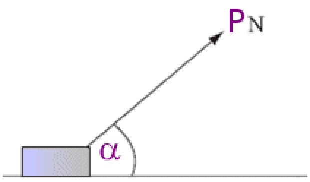
A sledge of mass 6 kg is at rest on a rough horizontal surface. A child tries to move the sledge by pushing it with a pole, as shown, but the sledge does not mov
The pole is at an angle of θ = 38° to the horizontal and exerts a force of P = 39 newtons on the sledge.
(a) Show that the normal reaction force between the sledge and the surface has magnitude 82.8 N
(b) Find the magnitude of the friction force that acts on the sledge.
(c) Find the least possible value of the coefficient of friction between the sledge and the surface.

Q113 - ID: 7347 *[8 marks, 10 minutes]*



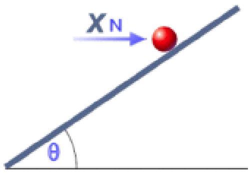
Parcels are often damaged when loaded onto a trolley, so a ramp is constructed down which parcels can slide onto the trolley. The ramp makes an angle of $\theta = 56°$ to the vertical, the distance $AB = 2.4\,m$ and the coefficient of friction between the ramp and a parcel is 0.2. A parcel of mass $2.6\,kg$ is released from rest at the top of the ramp (see diagram). Calculate the speed of the parcel after sliding down the ramp.

Q114 - ID: 7762 *[12 marks, 14 minutes]*



The diagram shows a block, of mass $15\,kg$, being pulled along a rough horizontal surface by a rope inclined at an angle of $\alpha = 34°$ to the horizontal The coefficient of friction between the block and the surface is μ. Model the block as a particle which slides on the surface.
If the tension, P, in the rope is 57 newtons, the block moves at a constant speed.
(a) Show that the magnitude of the normal reaction force acting on the block is 166 N
(b) Find μ.
(c) If the rope remains at the same angle and the block accelerates at $0.8\,ms^{-2}$, find the tension in the rope.

Q115 - ID: 7299 *[15 marks, 18 minutes]*



A particle of mass $0.6\,kg$ is held at rest on a rough plane. The plane is inclined at 29° to the horizontal. The particle is released from rest and slides down a line of greatest slope of the plane. The particle moves 2.2 m during the first 3 seconds of its motion. Find
(a) the acceleration of the particle,
(b) the coefficient of friction between the particle and the plane.
The particle is now held on the same rough plane by a horizontal force of magnitude X newtons, acting in a plane containing a line of greatest slope of the plane, as shown. The particle is in equilibrium and on the point of moving up the plane.
(c) Find the value of X.

Q116 - ID: 411

[11 marks, 13 minutes]

A truck, A, of mass 6 *tonnes* moves on straight horizontal rails. It collides with truck B of mass 3 *tonnes*, which is moving on the same rails. Immediately before the collision, the speed of A is $4\,ms^{-1}$ and the speed of B is $2\,ms^{-1}$ and the trucks are moving towards each other. In the collision, the trucks couple to form a single body C, which continues to move on the rails.
(a) Find the speed and direction of C after the collision.
(b) Find, in Ns, the magnitude of the impulse exerted by B on A in the collision.
(c) Immediately after the collision, a constant braking force of magnitude $240\,N$ is applied to C. It comes to rest in a distance d metres. Find the value of d.

Q117 - ID: 1949

[6 marks, 7 minutes]

Two small balls A and B have masses 0.7kg and 0.2kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 3 m/s and the speed of B is 2 m/s. The speed of A immediately after the collision is 1.7 m/s. The direction of motion of A is unchanged as a result of the collision.
By modelling the balls as particles, find
(a) the speed of B immediately after the collision,
(b) the magnitude of the impulse exerted on B in the collision.

Q118 - ID: 428

[3 marks, 4 minutes]

A ball of mass $0.4kg$ is moving vertically with speed $10ms^{-1}$ when it hits the floor which is smooth and horizontal. It rebounds vertically from the floor with speed $9ms^{-1}$. Find the magnitude of the impulse exerted by the floor on the ball.

Q119 - ID: 1950

[6 marks, 7 minutes]

A railway truck, A, of mass 1900 kg is moving along a straight horizontal track with speed 3 m/s. It collides directly with a stationary truck B of mass 1000 kg on the same track. In the collision, A and B are coupled and move off together.
(a) Find the speed of the trucks immediately after the collision.
After the collision, the trucks experience a constant resistive force of magnitude R newtons. They come to rest 8 s after the collision.
(b) Find R.

Q120 - ID: 1951

[7 marks, 8 minutes]

The masses of two particles A and B are $0.5kg$ and $m\,kg$ respectively. The particles are moving on a smooth horizontal table in opposite directions and collide directly. Immediately before the collision the speed of A is $4ms^{-1}$ and the speed of B is $1.5ms^{-1}$. In the collision, the magnitude of the impulse exerted by B on A is $1Ns$. As a result of the collision the direction of motion of A is reversed.
(a) Find the speed of A immediately after the collision,
The speed of B immediately after the collision is $0.7ms^{-1}$.
(b) Find the two possible values of m.

Q121 - ID: 1952

[11 marks, 13 minutes]

A railway truck, P, of mass 1800 kg is moving along a straight horizontal track. The truck P collides with a truck Q of mass 3000 kg at point A. Immediately before the collision, P and Q are moving in the same direction with speeds 9 m/s and 6 m/s respectively. Immediately after the collision, the direction of motion of P is unchanged and its speed is 4 m/s.
By modelling the trucks as particles,
(a) show that the speed of Q immediately after the collision is 9 m/s.
After the collision at A, the truck P is acted upon by a constant braking force of magnitude 400 N. The truck P comes to rest at the point B.
(b) Find the distance AB.
After the collision Q continues to move with constant speed 8.7 m/s.
(c Find the distance between P and Q at the instant when P comes to rest.

Q122 - ID: 1954 *[5 marks, 6 minutes]*

A railway truck, P, of mass 2300 kg is moving along a straight horizontal track with speed 9 m/s. The truck P collides with a truck Q of mass 2500 kg which is at rest on the same track. Immediately after the collision Q moves with speed 7 m/s.
Calculate
(a) the speed P immediately after the collision.
(b) the magnitude of the impulse exerted by P on Q during the collision.

Q123 - ID: 1956 *[7 marks, 8 minutes]*

Two particles A and B have mass 0.12kg and 0.14 kg respectively. They are initially at rest on a smooth horizontal table. Particle A is then given an impulse in the direction AB so that it moves with speed 5 m/s directly towards B.
(a) Find the magnitude of this impulse, stating clearly the units.
Immediately after the particles collide, the speed of A is 1.3 m/s, its direction of motion being unchanged.
(b) Find the speed of B immediately after the collision,
(c) Find the magnitude of the impulse exerted on A in the collision.

Q124 - ID: 804 *[8 marks, 10 minutes]*

Two small steel balls A and B have mass $0.2\,kg$ and $0.5\,kg$ respectively. They are moving towards each other in opposite directions on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is $7\,ms^{-1}$ and the speed of B is $4\,ms^{-1}$.
Immediately after the collision, the direction of motion of A is unchanged and the speed of B is 2 times the speed of A.
Find
(a) the speed of A immediately after the collision.
(b) the magnitude of the impulse exerted on B in the collision,

Q125 - ID: 618

[8 marks, 10 minutes]

Two particles A and B, of mass $2kg$ and $5kg$ respectively, are moving in the same direction on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is $2ms^{-1}$ and the speed of B is $3.5ms^{-1}$. In the collision, the particles join to form a single particle C.

(a) Find the speed of C immediately after the collision.

Two particles P and Q have mass $3kg$ and $m\,kg$ respectively. They are moving towards each other in opposite directions on a smooth horizontal table. Each particle has speed $2ms^{-1}$, when they collide directly. In this collision, the direction of motion of each particle is reversed. The speed of P immediately after the collision is $6ms^{-1}$ and the speed of Q is $4ms^{-1}$.

(b) Find the value of m

(c) Find the magnitude of the impulse exerted on Q in the collision.

Q126 - ID: 763

[7 marks, 8 minutes]

Two particles A and B have mass $0.5\,kg$ and $0.3\,kg$ respectively. They are moving in opposite directions on a smooth horizontal table and collide directly. Immediately before the collision, the speed of A is $7\,ms^{-1}$ and the speed of B is $4\,ms^{-1}$.

As a result of the collision, the direction of motion of B is reversed and its speed immediately after the collision is $2\,ms^{-1}$. Find

(a) the speed of A immediately after the collision, stating clearly whether the direction of motion of A is changed by the collision,

(b) the magnitude of the impulse exerted on B in the collision, stating clearly the units in which your answer is given.

Q127 - ID: 485 *[10 marks, 12 minutes]*

A particle P of mass $0.7\,kg$ is moving with speed $u\,ms^{-1}$
in a straight line on a smooth horizontal surface.
The particle P collides directly with a particle Q of
mass $0.4\,kg$, which is at rest on the table. Immediately
after the particles collide, P has speed $6\,ms^{-1}$ and Q
has speed $6\,ms^{-1}$. The direction of motion of P is reversed
by the collision. Find

(a) the value of u,

(b) The magnitude of the impulse exerted by P on Q.

Immediately after the collision, a constant force of
magnitude R newtons is applied to Q in the direction
directly opposite to the direction of motion of Q.
As a result Q is brought to rest in $1.1\,s$.

(c) Find the value of R.

Q128 - ID: 2956 *[5 marks, 6 minutes]*

Two particles, A and B, are moving on a smooth horizontal surface.

Particle A has mass $3\,kg$ and velocity $\begin{pmatrix} 3 \\ -8 \end{pmatrix} ms^{-1}$.

Particle B has mass $7\,kg$ and velocity $\begin{pmatrix} -5 \\ 7 \end{pmatrix} ms^{-1}$.

The two particles collide, and they coalesce during the collision.
in a straight line on a smooth horizontal surface.

(a) Find the velocity of the combined particles after the collision.

(b) Find the speed of the combined particles after the collision.

Q129 - ID: 7274 *[7 marks, 8 minutes]*

Two particles A and B, of mass $0.2\,kg$ and $m\,kg$ respectively, are moving in
opposite directions along the same straight horizontal line so that the particles
collide directly. Immediately before the collision, the speeds of A and B are $8ms^{-1}$
and $5ms^{-1}$ respectively. In the collision the direction of motion of each particle is reversed
and, immediately after the collision, the speed of each particle is $2ms^{-1}$. Find

(a) the magnitude of the impulse exerted by B on A in the collision,

(b) the value of m.

Q130 - ID: 7422 *[6 marks, 7 minutes]*

Two particles A and B have masses of 5 *kg* and 3 *kg* respectively.
They are moving along a straight horizontal line towards each other.
Each particle is moving with a speed of $7ms^{-1}$ when they collide.
(a) If the particles coalesce during the collision to form a single particle, find the speed of the combined particle after the collision.
(b) If, after the collision, A moves in the same direction as before the collision with speed $0.3ms^{-1}$, find the speed of B after the collision.

Q131 - ID: 2883 *[6 marks, 7 minutes]*

Two particles A and B have masses 6 *kg* and m *kg* respectively. They are moving towards each other in opposite directions on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is $8\,ms^{-1}$ and the speed of B is $3\,ms^{-1}$. Immediately after the collision, the direction of motion of A is unchanged and the speed of A is $2\,ms^{-1}$.
(a) Find the magnitude of the impulse exerted on A in the collision.
Immediately after the collision, the speed of B is $3\,ms^{-1}$.
(b) Find the value of m.

Q132 - ID: 3300 *[6 marks, 7 minutes]*

Two particles A and B have masses 0.8 *kg* and 0.8 *kg* respectively. The particles are initially at rest on a smooth horizontal table. Particle P is given an impulse of magnitude 4*Ns* in the direction AB.
(a) Find the speed of A immediately before it collides with B.
Immediately after the collision between A and B, the speed of B is $5ms^{-1}$.
(b) Show that immediately after the collision A is at rest.

Q133 - ID: 4576 *[5 marks, 6 minutes]*

An ice skater of mass 63 *kg* is moving in a straight line with speed $3ms^{-1}$ when she collides with a skater of mass 37 *kg* moving in the opposite direction along the same straight line with speed $2ms^{-1}$. After the collision the skaters move together with common speed in the same straight line.
Calculate their common speed and state their direction of motion.

Q134 - ID: 7304 *[5 marks, 6 minutes]*

Two particles, A and B, are moving on a horizontal plane when they collide and coalesce to form a single particle.
The mass of A is $7\,kg$ and the mass of B is $14\,kg$.

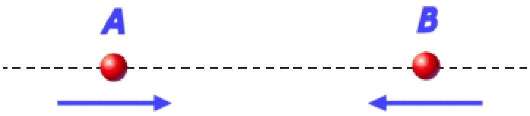
Before the collision, the velocity of A is $\begin{pmatrix} 3U \\ U \end{pmatrix} ms^{-1}$ and

the velocity of B is $\begin{pmatrix} V \\ -4 \end{pmatrix} ms^{-1}$.

After the collision, the velocity of the combined particle is $\begin{pmatrix} V \\ -1 \end{pmatrix} ms^{-1}$.

(a) Find U.
(a) Find V.

Q135 - ID: 7314 *[8 marks, 10 minutes]*



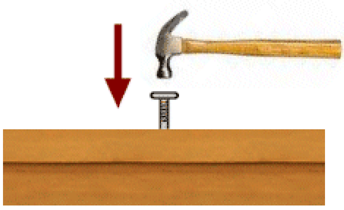
Two particles, A and B, are travelling towards each other along a straight horizontal line.
Particle A has velocity $4\,ms^{-1}$ and mass $m\,kg$.
Particle B has velocity $-4\,ms^{-1}$ and mass $3\,kg$.
The particles collide.
(a) If the particles move in opposite directions after the collision, each with speed $0.4\,ms^{-1}$, find the value of m.
(b) If the particles coalesce during the collision, forming a single particle which moves with speed $0.4\,ms^{-1}$, find the two possible values of m.

Q136 - ID: 7335 *[10 marks, 12 minutes]*

A railway wagon, A, of mass $2400\,kg$ and moving with speed $5\,ms^{-1}$ collides with railway wagon B of mass $3600\,kg$ and moving towards A with speed $3\,ms^{-1}$.
Immediately after the collision the speeds of A and B are equal.
(a) Given that after the collision the two wagons are moving in the same direction, find their common speed. State which wagon has changed its direction of motion.
Given instead that the two wagons are moving with equal speeds in opposite directions after the collision,
(b) Calculate the speed of the wagons.
(c) Calculate the change in momentum of A as a result of the collision.

Q137 - ID: 7401

[11 marks, 13 minutes]



Shown is a nail of mass $52\,g$ in a fixed block of wood. A hammer of mass $1.6\,kg$ strikes the nail directly with a vertical speed of $5.6\,ms^{-1}$. The hammer does not rebound from the nail.
(a) Find the velocity of the combined hammer and nail immediately after impact
The hammer and nail move together. The resistance to their motion is $1251\,N$.
(b) Find their acceleration.
(c) Find how far the hammer drives the nail into the block of wood.

Q138 - ID: 7405

[9 marks, 11 minutes]

Two ice hockey pucks, P and Q, moe towards each other.
P has mass $4m\,kg$ and is travelling at $4u\,ms^{-1}$
Q has mass $6m\,kg$ and is travelling at $3u\,ms^{-1}$
P collides directly with Q. Immediately after the collision both pucks have reversed their original directions of motion and P moves with a speed of $3u\,ms^{-1}$.
(a) Find, in terms of u, the speed of Q after the collision.
P subsequently collides directly with the ice rink wall and rebounds with a speed of $u\,ms^{-1}$.
(b) Find, in terms of m and u, the impulse exerted by the wall on P.

Q139 - ID: 5679

[9 marks, 11 minutes]

Two particles A and B are moving on a smooth horizontal plane.
The mass of A is km, where $2 < k < 3$, and the mass of B is m.
The particles are moving along the same straight line, but in opposite directions, and they collide directly. Immediately before they collide the speed of A is $4u$ and the speed of B is $6u$. As a result of the collision the speed of A is halved and its direction of motion is reversed.
(a) Find, in terms of k and u, the speed of B immediately after the collision.
(b) State whether the direction of motion of B changes as a result of the collision, explaining your answer.
(c) Given that $k = \frac{8}{3}$, find, in terms of m and u, the magnitude of the impulse that A exerts on B in the collision.

Q140 - ID: 6973 *[6 marks, 7 minutes]*

Two particles A and B are moving on a smooth horizontal plane.
The mass of A is $4m$ and the mass of B is m. The particles are moving along the same straight line but in opposite directions and they collide directly.
Immediately before they collide the speed of A is $4u$ and the speed of B is $2u$.
The magnitude of the impulse received by each particle in the collision is $\frac{8mu}{3}$.

(a) Find the speed of A immediately after the collision,
(b) Find the speed of B immediately after the collision.

Q141 - ID: 7316 *[3 marks, 4 minutes]*

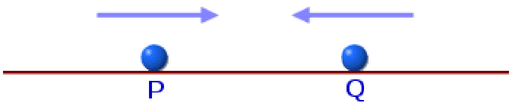
Two particles A and B are traveling in the same direction with constant speeds when they collide. Particle A has mass $2.2m$ and speed $10\,ms^{-1}$.
Particle B has mass $1.8m$ and speed $6\,ms^{-1}$
After the collision the two particles move together at the same speed.
Find the speed of the particles after the collision,

Q142 - ID: 7339 *[6 marks, 7 minutes]*

A particle P of mass $0.6\,kg$ is travelling with speed $8\,ms^{-1}$ on a smooth horizontal plane towards a stationary particle Q of mass $m\,kg$ (see diagram).
The particles collide, and immediately after the collision P has speed $0.9\,ms^{-1}$ and Q has speed $7\,ms^{-1}$

(a) Given that both particles are moving in the same direction after the collision, calculate m.
(b) Given instead that the particles are moving in opposite directions after the collision, calculate m.

Q143 - ID: 7348 *[12 marks, 14 minutes]*



Two particles P and Q have masses 0.6 *kg* and 0.4 *kg* respectively. P and Q are simultaneously projected towards each other in the same straight line on a horizontal surface with initial speeds of 7 ms^{-1} and 0.8 ms^{-1} respectively (see diagram).
Before P and Q collide the only horizontal force acting on each particle is friction and each particle decelerates at 0.4 ms^{-2} . The particles coalesce when they collide.
(a) Given that P and Q collide 1 *s* after projection, calculate the speed of each particle immediately before the collision, and the speed of the combined particle immediately after the collision.
(b) Given instead that P and Q collide 3 *s* after projection, calculate the distance between the two particles at the instant when they are projected.

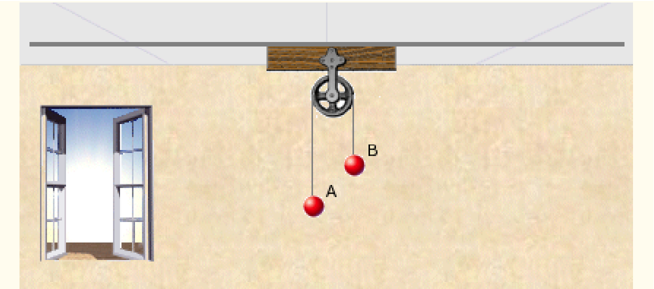
Q144 - ID: 7764 *[5 marks, 6 minutes]*

Two particles, A and B, are moving on a smooth horizontal surface when they collide.
During the collision, the two particles coalesce to form a single combined particle.
Particle A has mass 1 *kg* and particle B has mass 9 *kg*. Before the collision, the velocity of A is $\begin{pmatrix} 7 \\ -5 \end{pmatrix} ms^{-1}$ and the velocity of B is $\begin{pmatrix} -5 \\ 6 \end{pmatrix} ms^{-1}$
(a) Find the velocity of the combined particle after the collision.
(b) Find the speed of the combined particle after the collision.

Q145 - ID: 7268 *[6 marks, 7 minutes]*

A particle A of mass 3 *kg* is moving along a straight horizontal line with speed 14ms^{-1}. Another particle B of mass *m kg* is moving along the same straight line, in the opposite direction to A, with speed 8ms^{-1}. The particles collide.
The direction of motion of A is unchanged by the collision. Immediately after the collision, A is moving with speed 3ms^{-1} and B is moving with speed 4ms^{-1}. Find
(a) the magnitude of the impulse exerted by B on A in the collision,
(b) the value of *m*.

Q146 - ID: 1889 *[7 marks, 8 minutes]*

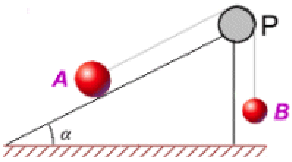


Two particles A and B have masses $2m$ kg and km kg, where $k > 2$. They are connected by a light inextensible string which passes over a smooth fixed pulley. The system is released form rest with the string taut and the hanging parts of the string vertical, as shown above. While the particles are moving freely, A has an acceleration of magnitude $\frac{3}{4}g$.

(a) Find, in terms of m and g, the tension, T, in the string.

(b) Find the value of k.

Q147 - ID: 1953 *[14 marks, 17 minutes]*



Two particles A and B, of mass m kg and 2 kg respectively, are connected by a light inextensible string. The particle A is held resting on a smooth fixed plane inclined at α= 30 degrees to the horizontal. The string passes over a smooth pulley P fixed at the top of the plane. The portion AP of the string lies along a line of greatest slope of the plane and B hangs freely from the pulley. The system is released from rest with B at the height of 0.25 m above horizontal ground. Immediately after release, B descends with an acceleration of 0.3 g.

Given that A does not reach P, calculate

(a) the tension, T, in the string while B is descending.

(b) the value of m.

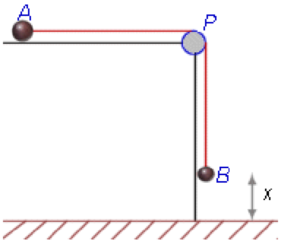
The particle B strikes the ground and does not rebound. Find

(c) the magnitude of the impulse exerted by B on the ground.

(d) the time between the instant when B strikes the ground and the instant when A reaches its highest point.

Q148 - ID: 1955

[16 marks, 19 minutes]



A particle A of mass 0.8 kg rests on a horizontal table and is attached to one end of a light inextensible string. The string passes over a smooth pulley P fixed at the edge of the table. The other end of the string is attached to a particle B of mass 1.4 kg which hangs freely below the pulley. The system is released from rest with the string taut and B at a height of x = 2.5 m above the ground. In the subsequent motion A does not reach P before B reaches the ground. In an initial model of the situation, the table is assumed to be smooth. Using this model, find

(a) the tension, T, in the string before B reaches the ground,

(b) the time taken by B to reach the ground.

In a refinement of the model, it is assumed that the table is rough and that the coefficient of friction between A and the table is $\frac{1}{4}$.

Using this refined model,

(c) find the time taken by B to reach the ground.

Q149 - ID: 1957

[13 marks, 16 minutes]

A car is being towed by a breakdown truck along a straight horizontal road. The truck has mass 1200 kg and the car has mass 800 kg. The truck is connected to the car by a horizontal rope which is modelled as light and inextensible. The truck engine provides a constant driving force of 2600 Ns. The resistance to motion of the truck and the car are modelled as constant and of magnitude 500N and 500N respectively.

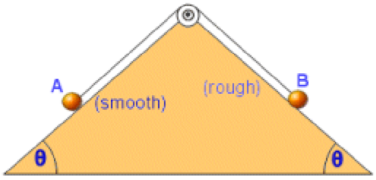
(a) Find the acceleration of the truck and the car.

(b) Find the tension in the rope.

When the truck and car are moving at 22 m/s the rope breaks. The truck engine provides the same driving force as before. The magnitude of the resistance to the motion of the truck remains 500N.

(c) Show that the truck reaches a speed of 31 m/s approximately 6 s earlier than it would have done if the rope had not broken.

Q150 - ID: 3158 *[14 marks, 17 minutes]*



A fixed wedge has two plane faces, each inclined at $\theta = 29°$ to the horizontal.
Two particles A and B, of mass $3m$ and m respectively, are attached to the ends of a light inextensible string. Each particle moves on one of the plane faces of the wedge. The string passes over a smooth light pulley fixed at the top of the wedge. The face on which A moves is smooth. The face on which B moves is rough. The coefficient of friction between B and this face is μ. Particle A is held at rest with the string taut. The string lies in the same vertical plane as lines of greatest slope on each plane face of the wedge, as shown.
The particles are released from rest and start to move. Particle A moves downwards and particle B moves upwards. The accelerations of A and B each have magnitude $\frac{1}{6}g$.

(a) By considering the motion of A, find, in terms of m and g, the tension in the string.
(b) By considering the motion of B, find the value of μ.
(c) Find the resultant force exerted by the string on the pulley, giving its magnitude and direction.

Q151 - ID: 7296 *[13 marks, 16 minutes]*

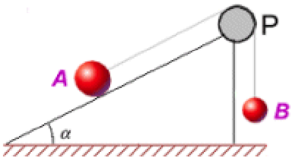
A car is towing a trailer along a straight horizontal road by means of a horizontal tow-rope. The mass of the car is 1290 kg. The mass of the trailer is 780 kg.
The car and the trailer are modelled as particles and the tow-rope as a light inextensible string. The resistances to motion of the car and the trailer are assumed to be constant and of magnitude 590 N and 270 N respectively. The driving force on the car, due to its engine, is 2310 N. Find

(a) the acceleration of the car,
(b) the tension in the tow-rope.

When the car and trailer are moving at 15 ms^{-1}, the tow-rope breaks. Assuming that the driving force on the car and the resistances to motion are unchanged,

(c) find the distance moved by the car in the first 3 s after the tow-rope breaks.
(d) State how you have used the modelling assumption that the tow-rope is inextensible.

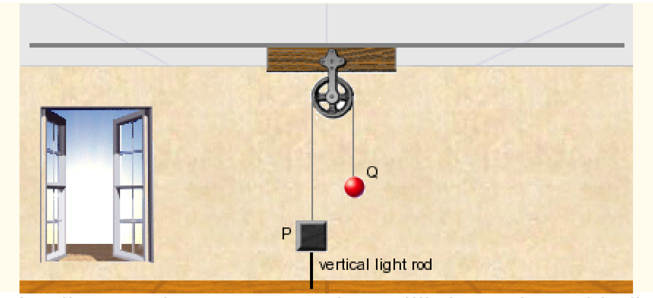
Q152 - ID: 530 *[16 marks, 19 minutes]*



The picture shows two particles *A* and *B*, of mass 3 *kg* and 5 *kg* respectively, connected by a light inextensible string. Initially *A* is held at rest on a fixed smooth plane inclined at $\alpha = 30°$ to the horizontal. The string passes over a small smooth light pulley *P* fixed at the top of the slope. The part of the string from *A* to *P* is parallel to a line of greatest slope of the plane. The particle *B* hangs freely below *A*. The system is released from rest with the string taut.

(a) Write down an equation of motion for *A* and an equation of motion for *B*.
(b) Hence show that the acceleration of *B* is $4.288\, ms^{-2}$.
(c) Find the tension in the string.
(d) State where in your calculations you have used the information that the string is inextensible.
On release, *B* is at a height of 0.7 *m* above the ground.
When *B* reaches the ground it is brought to rest immediately by the impact with the ground and does not rebound. The initial distance of *A* from *P* is such that in the subsequent motion *A* does not reach *P*. Find
(e) the speed of *B* as it reaches the ground.
(f) the time between the instant when *B* reaches the ground and the instant when the string becomes taut again.

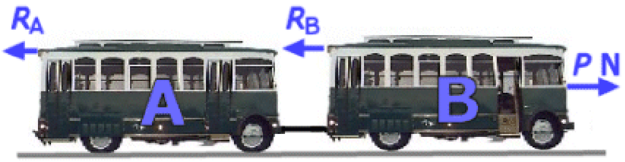
Q153 - ID: 2913 *[4 marks, 5 minutes]*



The diagram shows a system in equilibrium. The rod is firmly attached to the floor and also to an object, P, mass = 25 *kg*. The light string is attached to P and passes over a smooth pulley with an object Q, mass = 18 *kg*, hanging freely from its other end.
(a) Why is the tension the same throughout the string?
(b) Calculate the force, *F*, in the rod, stating whether it is a tension or a thrust.

Q154 - ID: 2914

[7 marks, 8 minutes]



Two trolleys, A and B, each of mass 10900 *kg*, are pulled along a straight, horizontal track by a constant, horizontal force of P N. The coupling between the trolleys is light and horizontal. The resistance to motion of trolley A is $R_A = 650\,n$ and of trolley B is $R_B = 200\,N$. The acceleration of the system is $0.3\,ms^{-2}$ in the direction of the pulling force of magnitude P.

(a) Calculate the value of P.

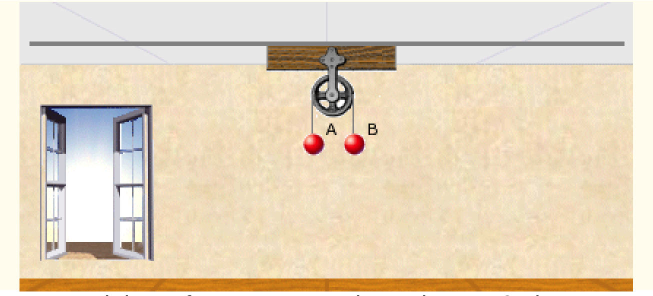
Trolley A is now subjected to an extra resistive force of 1800 N while P does not change.

(b) Calculate the new acceleration of the trucks.

(c) Calculate the force in the coupling between the trolleys.

Q155 - ID: 2958

[10 marks, 12 minutes]



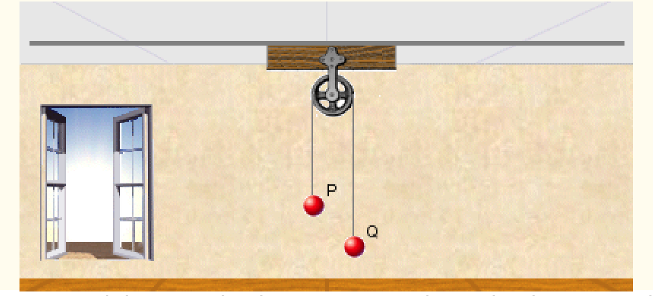
Two particles, of masses $A = 4\,kg$ and $B = 1.97\,kg$, are connected by a light string that passes over a smooth pulley. The particles are released from rest with the strings vertical, as shown.

(a) By forming an equation of motion for each particle, show that the magnitude of the acceleration of each particle is $3.33ms^{-2}$

(b) Find the tension in the string.

(c) Initially the particles are at the same level. Find the speed of the heavier particle when it is 2 m lower than the lighter particle. Assume that neither particle hits the floor or the peg.

Q156 - ID: 7281 *[17 marks, 20 minutes]*

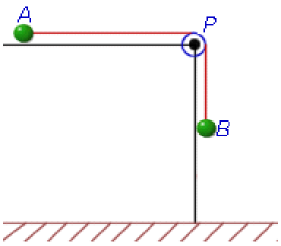


Two particles P and Q have mass 0.4 kg and $m\,kg$ respectively, where $m < 0.4$.
The particles are connected by a light inextensible string which passes over a smooth, fixed pulley. Initially P is 2.352 m above a horizontal floor. The particles are released from rest with the string taut and the hanging parts of the string vertical, as shown. After P has been descending for 1.4 s, it strikes the ground. Particle P reaches the floor before Q has reached the pulley.
(a) Show that the acceleration of P as it descends is $2.4ms^{-2}$.
(b) Find the tension in the string as P descends.
(c) Show that $m = 0.24$
(d) State how you have used the information that the string is inextensible.
When P strikes the floor, P does not rebound and the string becomes slack. Particle Q then moves freely under gravity, without reaching the pulley, until the string becomes taut again.
(e) Find the time between the instant when P strikes the floor and the instant when the string becomes taut again.

Q157 - ID: 7770 *[6 marks, 7 minutes]*

A car, of mass 1510 kg, is towing a caravan, of mass 950 kg, along a straight horizontal road. The caravan is connected to the car by a horizontal tow bar. Resistance forces of magnitudes470 N and 800 N act on the car and caravan respectively. The acceleration of the car and caravan is $0.7\,ms^{-2}$.
(a) Show that the magnitude of the force that the car exerts on the caravan is 1465 N.
(b) Find the magnitude of the driving force produced by the car's engine.

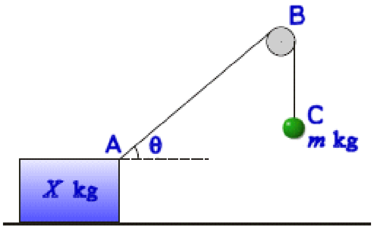
Q158 - ID: 2889 *[15 marks, 18 minutes]*



Two particles A and B, of mass m and $2m$ respectively, are attached to the ends of a light inextensible string. The particle A lies on a rough horizontal table. The string passes over a small smooth pulley P fixed on the edge of the table. The particle B hangs freely below the pulley, as shown above. The coefficient of friction between A and the table is μ. The particles are released from rest with the string taut. Immediately after release, the magnitude of the acceleration of A and B is $\frac{3}{8}g$. By writing down separate equations of motion for A and B,
(a) find the tension in the string immediately after the particles begin to move,
(b) show that $\mu = \frac{7}{8}$.
When B has fallen a distance h, it hits the ground and does not rebound. Particle A is then a distance $\frac{1}{4}h$ from P.
(c) Find the speed of A as it reaches P.
(d) State how you have used the information that the string is light.

Q159 - ID: 2907

[8 marks, 10 minutes]



The diagram shows a block of mass $X = 19\,kg$ on a rough, horizontal plane.
A light string is fixed to the block at A, passes over a smooth, fixed pulley B and is attached at C to a sphere. The section of the string between the block and the pulley is inclined at $\theta = 30°$ to the horizontal and the section between the pulley and the sphere is vertical. The system is in equilibrium and the tension in the string is $56.2\,N$.

(a) The sphere has a mass of $m\,kg$. Calculate the value of m.
(b) Calculate the frictional force acting on the block.
(c) Calculate the normal reaction of the plane on the block.

Q160 - ID: 4578

[14 marks, 17 minutes]

A car is pulling a trailer along a straight road using a light tow-bar which is parallel to the road. The masses of the car and trailer are $900\,kg$ and $250\,kg$ respectively. The resistance to motion of the car is $600\,N$ and the resistance to motion of the trailer is $150\,N$. The road is horizontal and the pulling force exerted on the trailer is zero.

(a) Show that the acceleration of the trailer is $-0.6\,ms^{-2}$.
(b) Find the driving force exerted by the car.
(c) Find the distance required to reduce the speed of the car and trailer from $18\,ms^{-1}$ to $15\,ms^{-1}$.

At another stage of the motion, the car and trailer are moving down a slope inclined at 3° to the horizontal. The resistance to motion of the car and trailer are unchanged. The driving force exerted by the car is $980\,N$.

(d) Find the acceleration of the car and trailer.
(e) Find the pulling force exerted on the trailer.

Q161 - ID: 5555

[15 marks, 18 minutes]

Two particles P and Q, of mass 4 kg and 3 kg respectively, are joined by a light inextensible string. Initially the particles are at rest on a rough horizontal plane with the string taut. A constant force F of magnitude 26 N is applied to Q in the direction PQ, as shown. The force is applied for 5 s and during this time Q travels a distance of 7 m. The coefficient of friction between each particle and the plane is μ . Find

(a) the acceleration of Q,

(b) the value of μ,

(c) the tension in the string.

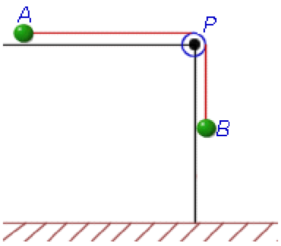
(d) State how in your calculation you have used the information that the string is inextensible.

When the particles have moved for 5 s, the force F is removed.

(e) Find the time between the instant that the force is removed and the instant that Q comes to rest.

Q162 - ID: 7310

[8 marks, 10 minutes]



Two particles, A and B, are connected by a light inextensible string, which passes over a smooth peg. Particle A is on a rough horizontal surface and has mass 6 kg. Particle B hangs freely, as shown in the diagram, and has mass 5 kg. The coefficient of friction between A and the horizontal surface is μ. The particles are released from rest and move with a constant acceleration of magnitude 0.9 ms^{-2}.

(a) Find the tension in the string.

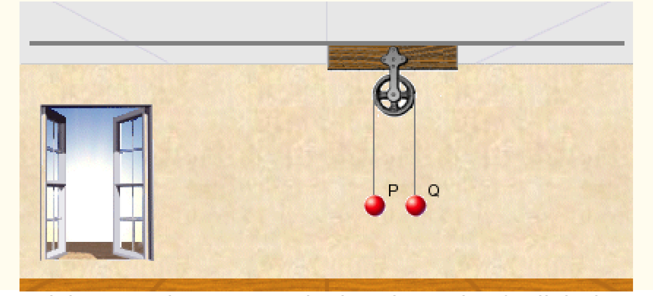
(b) Calculate the magnitude of the normal reaction force acting on A.

(c) Find the magnitude of the friction force that acts on A.

(d) Find μ.

Q163 - ID: 7330

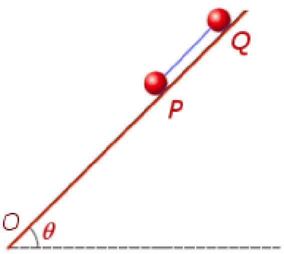
[15 marks, 18 minutes]



Particles P and Q are attached to the ends of a light inextensible string.
The string passes over a smooth fized pulley. The particles are released with the string taut, and P and Q at the same height above an horizontal floor, as shown.
In the subsequent motion P descends with constant acceleration $1\,ms^{-2}$ and strikes the floor $0.5\,s$ after being released. It is given that Q never reaches the pulley.
(a) Calculate the distance P moves before meeting the floor and the speed of P immediately before striking the floor.
(b) Show that Q rises a further $0.013\,m$ after P strikes the floor and calculate the total length of time during which Q is rising.
(c) Before P strikes the floor the tension in the string is $5.92\,N$. Calculate the mass of P and the mass of Q.
The pulley has mass $0.4\,kg$ and is held in position by a light vertical chain. Calculate the tension in the chain
(d) immediately before P strikes the floor.
(e) immediately after P strikes the floor.

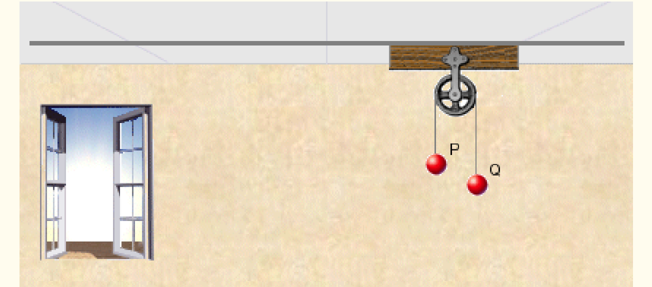
Q164 - ID: 7337

[16 marks, 19 minutes]



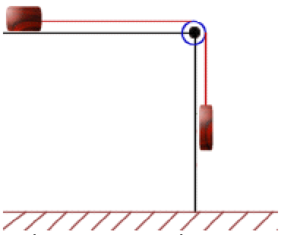
Two particles P and Q are joined by a taut light inextensible string which is parallel to a line of greatest slope on an inclined plane on which the particles are initially held at rest. The string is $0.8\,m$ long and the plane is inclined at $\theta = 45°$ to the horizontal, as shown.
P is below Q and initially is $4\,m$ from the foot of the plane at O.
Each particle has mass $0.4\,kg$. Contact between P and the plane is smooth.
The coefficient of friction between Q and the plane is 1. The particles are released from rest and begin to move down the plane.
(a) Show that the magnitude of the frictional force acting on Q is $2.772\,N$ correct to 4 significant figures.
(b) Show that the particles accelerate at $3.465\,ms^{-2}$ correct to 4 significant figures an calculate the tension in the string.
(c) Calculate the speed of the particles at the instant when Q reaches the initial position of P.
At the instant when Q reaches the initial position of P, Q becomes detached from the string and both particles travel independently to the foot of the plane.
(d) Show that Q descends at constant speed, and calculate the time interval between the arrival of P and the arrival of Q at the foot of the plane.

Q165 - ID: 7390 *[6 marks, 7 minutes]*



Two particles P and Q, of mass 3 kg and 6 kg respectively, are connected by a light inextensible string passing over a smooth light pulley, as shown in the diagram. Initially, the particles are held at rest with the string taut. The system is then released. Calculate the magnitude of the acceleration of the particle P and the tension in the string.

Q166 - ID: 7399 *[8 marks, 10 minutes]*



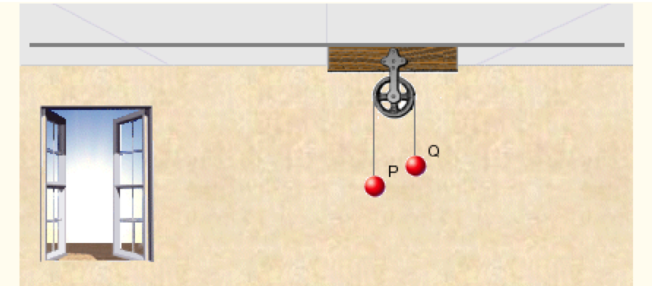
A box, mass m kg, rests on a smooth horizontal table. It is attached to one end of a light inextensible string. The string passes over a smooth pulley fixed at the edge of the table. The other end of the string is attached to a second box, mass $5m$ kg, which hangs vertically below the pulley as shown. The system is released from rest.

(a) Show that the acceleration of the boxes is $\frac{5g}{6}$ ms^{-2}

At a certain instant the boxes have a speed of u ms^{-1}. S seconds later the speed of the boxes has doubled.

(b) Find S in terms of u and g.

Q167 - ID: 7407 *[12 marks, 14 minutes]*



Two blocks, P and Q, of mass 5 kg and 8 kg respectively are connected by a light inextensible string which passes over a smooth fixed pulley. The system is released from rest.

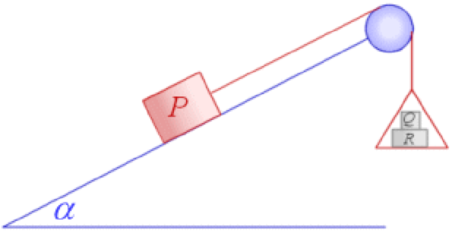
(a) Find the acceleration of the blocks and the tension in the string.

The string is cut when the blocks are moving with a speed of 0.6 ms^{-1}.

(b) Find how much further the 5 kg block ascends before coming to rest.

Q168 - ID: 5715

[16 marks, 19 minutes]



One end of a light inextensible string is attached to a block P of mass 6 kg. The block P is held at rest on a smooth fixed plane which is inclined to the horizontal at an angle α, where $\sin\alpha = \frac{3}{5}$. The string lies along a line of greatest slope of the plane and passes over a smooth light pulley which is fixed at the top of the plane. The other end of the string is attached to a light scale pan which carries two blocks Q and R, with block Q on top of block R, as shown in the diagram. The mass of block Q is 3 kg and the mass of block R is 8 kg. The scale pan hangs at rest and the system is released from rest. By modelling the blocks as particles, ignoring air resistance and assuming the motion is uninterrupted, find

(a) the acceleration of the scale pan,
(b) the tension in the string,
(c) the magnitude of the force exerted on block Q by block R,
(d) the magnitude of the force exerted on the pulley by the string.

Q169 - ID: 6976

[13 marks, 16 minutes]

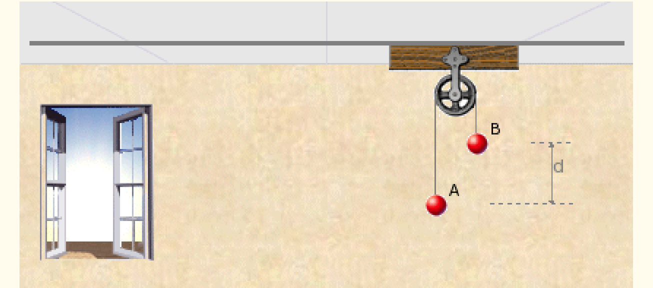
A car of mass 760 kg pulls a trailer of mass 240 kg along a straight horizontal road using a light towbar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 400 N and 200 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1000 N.

(a) Find the acceleration of the car and trailer,
(b) Find the magnitude of the tension in the towbar.

The car is moving along the road when the driver sees a hazard ahead. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 90 N,

(c) find the value of F.

Q170 - ID: 7318 *[14 marks, 17 minutes]*



Two particles, A and B are connected by a string that passes over a fixed pulley, as shown. The mass of A is 8 kg and the mass of B is 10 kg. The particles are released from rest in the position shown where B is d m higher than A.
The motion of the particles is to be modelled using simple assumptions.
(a) State one assumption that should be made about the pulley.
(b) State two assumptions that should be made about the string.
(c) By forming an equation of motion for each of the particles A and B, show that the acceleration of each particle has magnitude 1.09 ms^{-2}
When the particles have been moving for 0.8 seconds they are at the same level.
(d) Find the speed of the particles at this time.
(e) Find d.

Q171 - ID: 7340 *[9 marks, 11 minutes]*

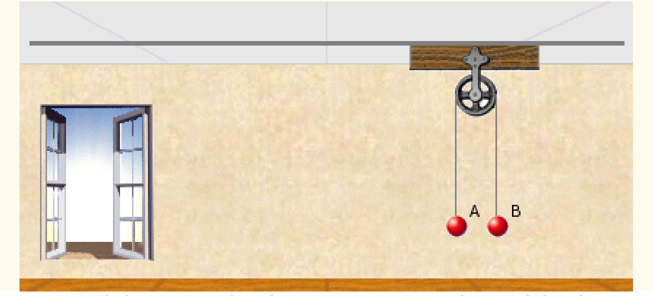
A trailer of mass 460 kg is attached to a car of mass 1300 kg by a light rigid horizontal tow-bar. The car and trailer are travelling along a horizontal straight road. The resistance to motion of the trailer is 370 N and the resistance to motion of the car is 880 N. Find both the tension in the tow-bar and the driving force of the car in each of the following cases.
(a) The car and trailer are travelling at constant speed.
(b) The car and trailer have acceleration 0.3 ms^{-2}.

Q172 - ID: 7765 *[9 marks, 11 minutes]*

A car, of mass 1220 kg, is towing a trailer, of mass 700 kg. The two vehicles accelerate together at 1.5 ms^{-2} along a straight horizontal road.
(a) Find the distance that the car and trailer would travel while accelerating from rest to 14 ms^{-1}
A forward driving force, of magnitude 3730 N, acts on the car.
A resistance force, of magnitude 800 N, also acts on the car.
(b) A resistance force, of magnitude P newtons, acts on the trailer. Find P.
(c) Find the magnitude of the force that the car exerts on the trailer.

Q173 - ID: 7300

[14 marks, 17 minutes]



Two particles, A and B have masses $7m$ kg and km kg respectively, where $k < 7$.
The particles are connected by a light string that passes over a smooth light fixed pulley. The system is held at rest with the string taut, the hanging parts of the string vertical and with A and B at the same height above a horizontal floor, as shown. The system is released from rest. After release, A descends with acceleration $\frac{1}{4}g$.

(a) Show that the tension in the string as A descends is $\frac{21}{4}mg$.

(b) Find the value of k.

(c) State how you have used the information that the pulley is smooth.

After descending for 1.8 s, the particle A reaches the floor. It is immediately brought to rest by the impact with the floor. The initial distance between B and the pulley is such that, in the subsequent motion, B does not reach the pulley.

(d) Find the greatest height reached by B above the floor.

Q174 - ID: 855

[11 marks, 13 minutes]

A particle P, of mass 6 kg moves under the action of two constant forces $(5\underline{i} + 3\underline{j})N$ and $(4\underline{i} - 7\underline{j})N$.

(a) Find in the form $(a\underline{i} + b\underline{j})N$, the resultant force F acting on P.

(b) Find in degrees to 1 decimal place, the angle between F and $\underline{j}$.

(c) Find the acceleration of P, giving your answer as a vector.

The initial velocity of P is $(-2\underline{i} + 3\underline{j})ms^{-1}$.

(d) Find the speed of P after 3s.

Q175 - ID: 892

[7 marks, 8 minutes]

A particle P, of mass 3kg is moving under the action of a constant force $(3\underline{i} - 9\underline{j})N$. Initially P has velocity $(2\underline{i} + 2\underline{j})ms^{-1}$.

Find

(a) the magnitude of the acceleration of P.

(b) the velocity of P in terms of $\underline{i}$ and $\underline{j}$ when P has been moving for 2 seconds.

Q176 - ID: 509

[6 marks, 7 minutes]

A particle P, of mass 0.3 kg is moving under the action of a constant force F Newtons. Initially the velocity of P is $(7\underline{i} - 23\underline{j})$ ms^{-1} and 2 s later the velocity of P is $(-14\underline{i} + 18\underline{j})$ m^{-1}.

(a) Find in terms of i and j, the acceleration of P.

(b) Calculate the magnitude of F.

Q177 - ID: 1948 *[14 marks, 17 minutes]*

A ball is projected vertically upward with speed u m/s from a point A which is 1.6 above the ground. The ball moves freely under gravity until it reaches the ground. The greatest height attained by the ball is 26.7 m above A.
(a) Show that u = 22.876
The ball reaches the ground T seconds after it was projected from A.
(b) Find, to 2 decimal places, the value of T.
The ground is soft and the ball sinks 2.8 cm into the ground before coming to rest. The mass of the ball is 0.7 kg. The ground is assumed to exert a constant resistive force of magnitude F newtons.
(c) Find, to 3 significant figures, the value of F.
(d) State one physical factor which could be taken into account to make the model used in this question more realistic.

Q178 - ID: 712 *[9 marks, 11 minutes]*

A particle P of mass $2\,kg$ is moving under the action of a constant force F newtons. When $t = 0$, P has velocity $(3\underline{i} + 5\underline{j})\ ms^{-1}$ and at time $t = 2$, P has velocity $(11\underline{i} - 5\underline{j})ms^{-1}$. Find

(a) the acceleration of P in terms of $\underline{i}$ and $\underline{j}$.

(b) the magnitude of F.

(c) the velocity of P at time $t = 5\,s$.

Q179 - ID: 2916 *[8 marks, 10 minutes]*

A rock of mass $5\,kg$ is acted on by just the two forces $-89\underline{k}$ and $(-2\underline{i} + 20\underline{j} + 72\underline{k})$, where $\underline{i}$ and $\underline{j}$ are perpendicular unit vectors in a horizontal plane and $\underline{k}$ is a unit vector vertically upward.

(a) Show that the acceleration of the rock is $(-0.4\underline{i} + 4\underline{j} - 3.4\underline{k})\ ms^{-2}$.

The rock passes through the origin of position vectors, O, with velocity $(2\underline{i} - 6\underline{j} + 4\underline{k})\ ms^{-1}$ and 3 seconds later passes through the point A.

(b) Find the position vector of A.
(c) Find the distance OA.
(d) Find the angle that OA makes with the horizontal.

Q180 - ID: 7773 *[8 marks, 10 minutes]*

A trolley, of mass 93 kg, rolls at a constant speed along a straight line down a slope inclined at an angle of 5° to the horizontal.
Assume that a constant resistance force, of magnitude P newtons, acts on the trolley as it moves. Model the trolley as a particle.
(a) Show that $P = 79.4\,N$, correct to three significant figures.
(b) Find the acceleration of the trolley if it rolls down a slope inclined at 7° to the horizontal and experiences the same constant force of magnitude P that you found in part (a).
(c) Make one criticism of the assumption that the resistance force on the trolley is constant.

Q181 - ID: 2905 *[7 marks, 8 minutes]*

The force acting on a particle of mass 1.2 kg is given by the vector $\begin{pmatrix} 9 \\ 6 \end{pmatrix} N$

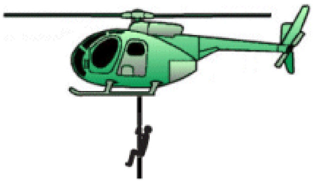
(a) Give the acceleration of the particle as a vector.

(b) Calculate the angle that the acceleration makes with the direction $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$

(c) At a certain point of its motion, the particle has a velocity of $\begin{pmatrix} -8 \\ 5 \end{pmatrix} ms^{-1}$.

Calculate the displacement of the particle over the next 5 seconds.

Q182 - ID: 2909 *[17 marks, 20 minutes]*



(a) When the man is descending with an acceleration $1.8\,ms^{-2}$ downwards, how much time does it take for his speed to increase from $0.8\,ms^{-1}$ downwards to $3.1\,ms^{-1}$ downwards? How far does he descend in this time?
The man has a mass of 76 kg. All resistances to motion may be neglected.
(b) Calculate the tension in the wire when the man is being lowered (i) with an acceleration of $1.8\,ms^{-2}$ downwards, (ii) with an acceleration of $1.8\,ms^{-2}$ upwards.
(c) Subsequently, the man is raised and this situation is modelled with a constant resistance of 127 N to his upward motion. For safety reasons, the tension in the wire should not exceed 1900 N. What is the maximum acceleration allowed when the man is being raised?
At another stage of the rescue, the man has equipment of mass 9 kg at the bottom of a vertical rope which is hanging from his waist. The man and his equipment are being raised; the rope is light and inextensible and the tension in it is 83 N.
(d) Assuming that the resistance to the upward motion of the man is still 127 N and that there is negligible resistance to the motion of the equipment, calculate the tension in the wire.

Q183 - ID: 3302 *[8 marks, 10 minutes]*

A particle P of mass 0.3 *kg* moves under the action of a single constant force F newtons.
The acceleration of P is $(7i + 9j)\ ms^{-2}$. Find
(a) the angle between the acceleration and i,
(b) the magnitude of F.
(At time t seconds the velocity of P is $v\,ms^{-1}$. Given that when $t = 0$, $v = 9i - 10j$,
(c) find the velocity of P when $t = 5$.

Q184 - ID: 4574 *[4 marks, 5 minutes]*

A man of mass 75 *kg* stands on the floor of a lift which is
moving with an upward acceleration of $0.7\,ms^{-2}$.
Calculate the magnitude of the force exerted by the floor on the man.

Q185 - ID: 5459 *[8 marks, 10 minutes]*

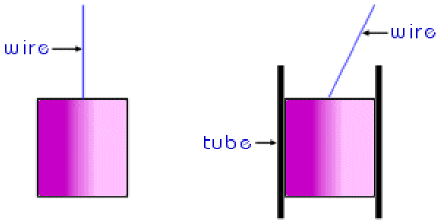


Fig.1 Fig.2

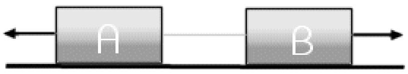
Figure 1 shows a circular cylinder of mass 90kg being raised by a
light inextensible vertical wire. There is negligible air resistance.
(a) Calculate the acceleration in the cylinder when the tension in the wire is 930N.
(b) Calculate the tension in the wire when the cylinder has an upward acceleration of $0.6\,ms^{-2}$.
The cylinder is now raised within a fixed vertical tube that prevents horizontal motion but
provides negligible resistance to the upward motion of the cylinder.
When the wire is inclined at 23° to the vertical, as shown in Figure 2, the cylinder again
has an upward acceleration of $0.6\,ms^{-2}$.
(c) Calculate the new tension in the wire.

Q186 - ID: 5460 *[5 marks, 6 minutes]*

An object of mass 7 kg has a constant acceleration of $\begin{pmatrix} -5 \\ 3 \end{pmatrix} ms^{-2}$ for $0 \leq t \leq 4$

where t is the time in seconds.
(a) Calculate the force acting on the object.
When $t = 0$ the object has position vector $\begin{pmatrix} -2 \\ 5 \end{pmatrix}$ and velocity $\begin{pmatrix} 6 \\ 6 \end{pmatrix} ms^{-1}$.
(b) Find the position vector of the object when $t = 4$.

Q187 - ID: 5462 *[4 marks, 5 minutes]*



Boxes A and B slide on a smooth horizontal plane. Box A has a mass of $3\,kg$ and box B has a mass of $7\,kg$. They are connected by a light inextensible horizontal wire. Horizontal forces of $6\,N$ and $134\,N$ act on A and B in the directions indicated.
Calculate the tension in the wire joining the blocks.

Q188 - ID: 7301 *[6 marks, 7 minutes]*

A crane is used to lift a crate, of mass $63\,kg$, vertically upwards.
As the crate is lifted, it accelerates uniformly from rest, rising 7 metres in 4 seconds.
(a) Show that the acceleration of the crate is $0.88\,ms^{-2}$.
(b) The crate is attached to the crane by a single cable. Assume that there is no resistance to the motion of the crate. Find the tension in the cable.
(c) Calculate the average speed of the crate during these 5 seconds.

Q189 - ID: 7332 *[6 marks, 7 minutes]*

A car, of mass $870\,kg$, is travelling in a straight line on a horizontal road.
The driving force acting on the car is $640\,N$, and a resisting force of $250\,N$ opposes the motion.
(a) Show that the acceleration of the car is $0.45\,ms^{-2}$.
(b) Calculate the time and the distance required for the speed of the car to increase from $2\,ms^{-1}$ to $5\,ms^{-1}$.

Q190 - ID: 7389 *[6 marks, 7 minutes]*

The mass of a lift is $410\,kg$. When a man, of mass $67\,kg$, is standing in the lift and the tension in the cable is $4650\,N$, the lift is descending with acceleration $a\,ms^{-2}$.
(a) Find the value of a.
(b) Determine the reaction of the floor of the lift on the man.

Q191 - ID: 7403

[8 marks, 10 minutes]

A car of mass 480 kg is travelling along a straight horizontal road. The engine of the car exerts a force of 3160 N. The total resistance to motion is 2170 N.
(a) Find the acceleration of the car.
The car travels from A to B, a distance of 150 m, in a time of 7 s.
(b) Find the speed of the car at A.
(c) Find the speed of the car at B.

Q192 - ID: 7317

[7 marks, 8 minutes]

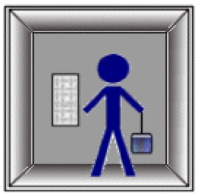
A box of mass 4 kg is held at rest on a plane inclined at 41° to the horizontal. The box is then released and slides down the plane.
(a) A simple model assumes that the only forces acting on the box are its weight and the normal reaction from the plane. Show that, according to this simple model, the acceleration of the box would be 6.4 ms^{-2}, correct to 3 significant figures.
(b) In fact the box moves down the plane with constant acceleration and travels 0.5 metres in 0.4 seconds. By using this information, find the acceleration of the box.
(c) Explain why the answer to (b) is less than the answer to (a).

Q193 - ID: 7326

[10 marks, 12 minutes]

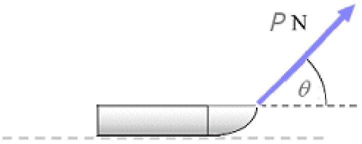
Two forces, $P = (8i - 5j)$ newtons and $Q = (-3.6i + 17j)$ newtons, act on a particle.
The unit vectors i and j are perpendicular.
(a) Find the resultant of P and Q.
(b) Find the magnitude of the resultant of P and Q.
When these two forces act on the particle, it has an acceleration of $(1.1i + 3j)$ ms^{-2}
(c) Find the mass of the particle.
The particle was originally at rest at the origin.
(d) Find an expression for the position vector of the particle when the forces have been applied to the particle for t seconds.
Find the distance of the particle from the origin after the forces have been applied for 3 seconds.

Q194 - ID: 7356 *[5 marks, 6 minutes]*



A man of mass 78 kg is standing in a lift. He is holding a parcel of mass 3 kg by means of a light inextensible string, as shown. The tension in the string is 39 N.
(a) Find the upward acceleration.
(b) Find the reaction on the man of the lift floor.

Q195 - ID: 7358 *[15 marks, 18 minutes]*

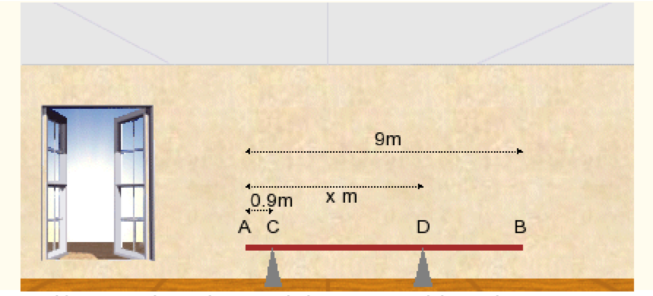


An explorer is trying to pull a loaded sledge of total mass 93 kg along horizontal ground using a light rope. The only resistance to motion of the sledge is from friction between it and the ground. Initially she pulls with a force of $P = 122\,N$ on the rope inclined at $\theta = 31°$ to the horizontal, as shown, but the sledge does not move.
(a) Show that the frictional force between the ground and the sledge is 105 N, correct to 3 significant figures.
(b) Calculate the normal reaction of the ground on the sledge.
The sledge is given a small push to set it moving at 0.4 ms^{-1}. The explorer continues to pull on the rope with the same force and the same angle as before. The frictional force is also unchanged.
(c) Describe the subsequent motion of the sledge.
The explorer now pulls the rope, still at an angle of 31° to the horizontal, so that the tension in it is 150 N. The frictional force is now 99 N.
(d) Calculate the acceleration of the sledge.
In a new situation, there is no rope and the sledge slides down a uniformly rough slope inclined at 28° to the horizontal. The sledge starts from rest and reaches a speed of 3 ms^{-1} in 2 seconds.
(e) Calculate the frictional force between the slope and the sledge.

Q196 - ID: 7763 *[6 marks, 7 minutes]*

A motorcycle and rider, of total mass 320 kg, are accelerating in a straight line along a horizontal road at 2.4 ms^{-2}.
(a) Show that the magnitude of the resultant force acting on the motorcycle is 768 N.
(b) A forward driving force of P newtons together with a resistance force of magnitude 440 newtons act on the motorcycle. Find P.
(c) Find the time that it would take for the speed of the motorcycle to increase from 13 ms^{-1} to 20 ms^{-1}.

Q197 - ID: 746 *[6 marks, 7 minutes]*

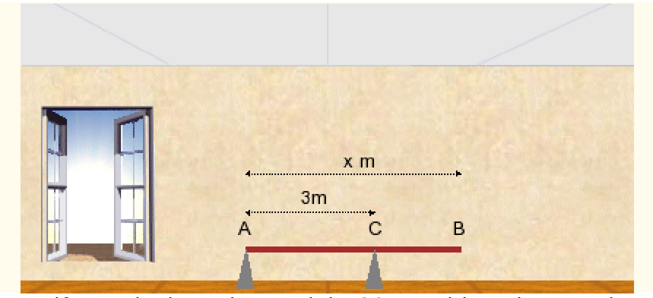


A uniform rod AB has weight 95N and length 9m. It rests in a horizontal position on two smooth supports placed at C and D, where AC = 0.9m as shown above. The reaction on the rod at C has magnitude 25N. Find

(a) the magnitude of the reaction on the rod at D.

(b) the distance AD.

Q198 - ID: 691 *[8 marks, 10 minutes]*



A uniform plank AB has weight 80N and length x m. The plank rests in equilibrium on two smooth supports placed at A and C, where AC = 3m as shown above. A rock of weight 20N is placed at B and the plank remains in equilibrium. The reaction on the plank at C has magnitude 100N.

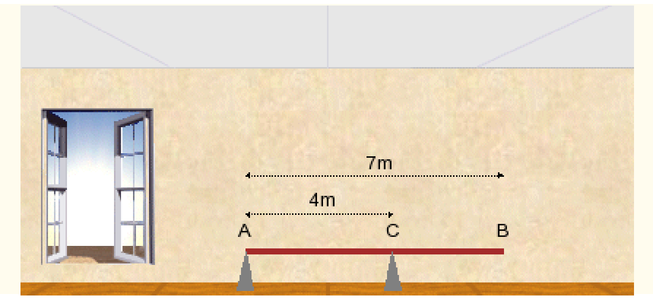
The plank is modelled as a rod and the rock as a particle.

(a) Find the value of x.

The support at A is now moved to a point D on the plank and the plank remains in equilibrium with the rock at B. The reaction on the plank at C is now 3 times the reaction at D.

(b) Find the distance AD.

Q199 - ID: 717 *[6 marks, 7 minutes]*



A uniform plank AB has mass 50*kg* and length 7*m*. It is supported in a horizontal position by two smooth pivots, one at the end A, the other at the point C of the plank where $AC = 4m$. as shown above. A man of mass 75*kg* stands on the plank which remains in equilibrium. The magnitudes of the reactions at the two pivots are each equal to R newtons.

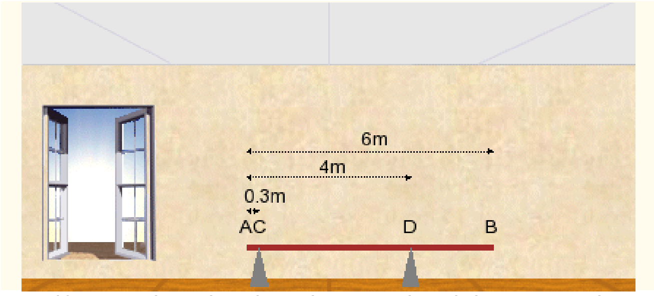
By modelling the plank as a rod and the man as a particle, find

(a) the value of R.

(b) the distance of the man from A.

Q200 - ID: 871

[10 marks, 12 minutes]



A uniform rod AB has length 6*m* and weight 110*N*. The rod rests in equilibrium in a horizontal position, smoothly supported at points C and D, where AC = 0.3*m* and $AD = 4m$. A particle of weight W newtons is attached to the rod at a point E where $AX = x\,m$.

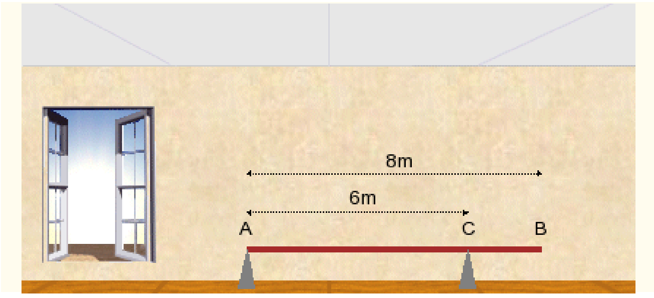
The rod remains in equilibrium and the magnitude of the reaction at C is now 2 times the magnitude of the reaction at D.

(a) Show that $W = \dfrac{484}{4.6 - 3x}$

(b) Hence deduce the range of possible values of x.

Q201 - ID: 3073

[10 marks, 12 minutes]



A uniform plank AB has mass 9*kg* and length 8*m*. The beam rests in equilibrium in a horizontal position, resting on two smooth supports. One support is at end A, the other at a point C on the beam, where $AC = 6m$, as shown. The beam is modelled as a uniform rod.

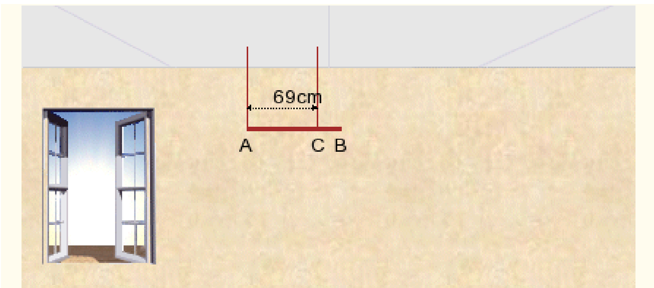
(a) Find the reaction on the beam at C.

A woman of mass 40*kg* stands on the beam at the point D. The beam remains in equilibrium. The reactions on the beam at A and C are now equal.

(b) Find the distance AD.

Q202 - ID: 7295

[13 marks, 16 minutes]



A steel girder AB has weight 216 N. It is held in equilibrium in a horizontal position by two vertical cables. One cable is attached to the end A. The other able is attached to the point C on the girder, where AC = 69 cm, as shown. The girder is modelled as a uniform rod, and the cables as light inextensible strings. Given that the tension in the cable at C is 2 times the tension in the cable at A,

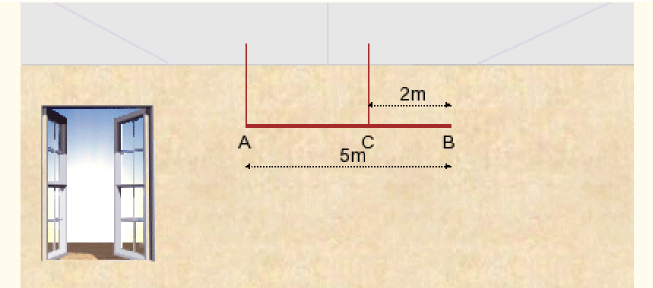
(a) find the tension in the cable at A,

(b) show that AB = 92 cm.

A small load of weight W newtons is attached to the girder at B. The load is modelled as a particle. The girder remains in equilibrium in a horizontal position. The tension in the cable at C is now 4 times the tension in the cable at A.

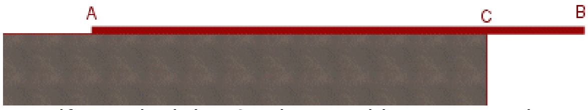
(c) Find the value of W.

Q203 - ID: 3260 *[5 marks, 6 minutes]*



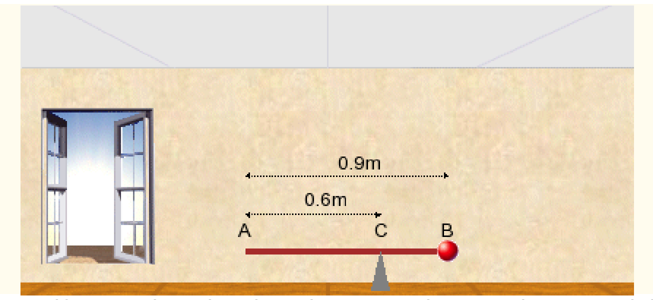
A uniform plank AB has mass 30*kg* and length 5*m*.
It is supported in equilibrium in a horizontal position by two vertical inextensible ropes. One of the ropes is attached to the plank at A and the other rope to the point C, where $BC = 2\,m$, as shown.
Find the tension in each rope.

Q204 - ID: 3269 *[9 marks, 11 minutes]*



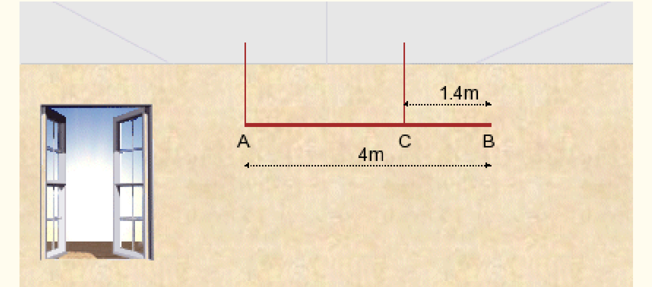
A uniform plank is 16 *m* long and has mass 14 *kg* . It is placed on horizontal ground at the edge of a vertical river bank, so that 3 *m* of the plank is projecting over the edge, as shown in the diagram.
(a) A woman of mass 47 *kg* stands on the part of the plank which projects over the river. Find the greatest distance from the river bank at which she can safely stand.
(b) The woman wishes to stand safely at the end of the plank which projects over the river. Find the minimum mass which she should place on the other end of the plank so that she can do this.
(c) State how you have used the fact that the plank is uniform in your solution.
(d) State one other modelling assumption which you have made.

Q205 - ID: 7275 *[9 marks, 11 minutes]*



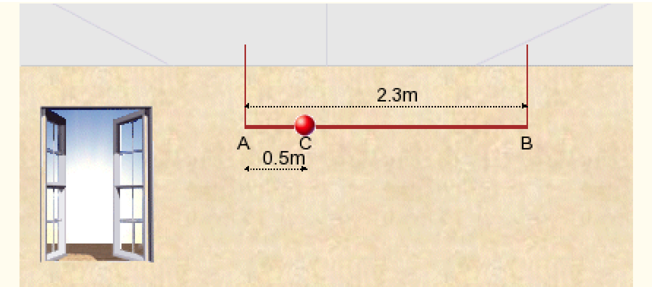
A uniform rod AB has length 0.9*m* and mass 8*kg*. A particle of mass *m kg* is attached to the rod at B. The rod is supported at the point C, where $AC = 0.6m$, and the system is in equilibrium with AB horizontal, as shown.
(a) Show that $m = 4$.
A particle of mass 7*kg* is now attached to the rod at A and the support is moved from C to a point D of the rod. The system, including both particles, is again in equilibrium with AB horizontal.
(b) Find the distance AD.

Q206 - ID: 2887 *[11 marks, 13 minutes]*



A beam AB has mass 12 kg and length 4 m. It is held in equilibrium in a horizontal position by two vertical ropes attached to the beam. One rope is attached to A, the other to the point C on the beam, where BC = 1.4 m, as shown. The beam is modelled as a uniform rod, and the ropes as light strings.
(a) Find the tension in the rope at C.
(b) Find the tension in the rope at A.
A small load of mass 19 kg is attached to the beam at a point which is y metres from A. The load is modelled as a particle. Given that the beam remains in equilibrium in a horizontal position,
(c) find, in terms of y, an expression for the tension in the rope at C.
The rope at C will break if its tension exceeds 91 N. The rope at A cannot break.
(d) Find the range of possible positions on the beam where the load can be attached without the rope at C breaking.

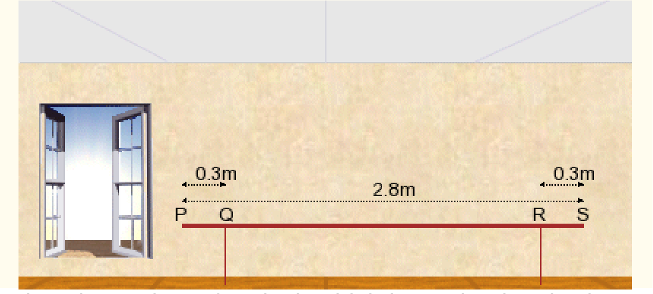
Q207 - ID: 3304 *[10 marks, 12 minutes]*



A beam AB has mass 16 kg and length 2.3 m. A load of mass 8 kg is attached to the plank at the point C, where $AC = 0.5\,m$.
The loaded plank is held in equilibrium, with AB horizontal, by two vertical ropes, one attached at A and the other attached at B, as shown.
The plank is modelled as a uniform rod, the load as a particle and the ropes as light inextensible strings.
(a) Find the tension in the rope attached at B.
The plank is now modelled as a non-uniform rod. With the new model, the tension in the rope attached at A is 13 N greater than the tension in the rope attached at B.
(b) Find the distance of the centre of mass of the plank from A.

Q208 - ID: 5713

[13 marks, 16 minutes]



A bench consists of a plank which is resting in a horizontal position on two thin vertical legs. The plank is modelled as a uniform rod PS of length 2.8 m and mass 18 kg. The legs at Q and R are 0.3 m from each end of the plank, as shown in the diagram.

Two pupils, Arthur and Beatrice, sit on the plank. Arthur has mass 62 kg and sits at the middle of the plank and Beatrice has mass 26 kg and sits at the end P. The plank remains horizontal and in equilibrium.

By modelling the pupils as particles, find

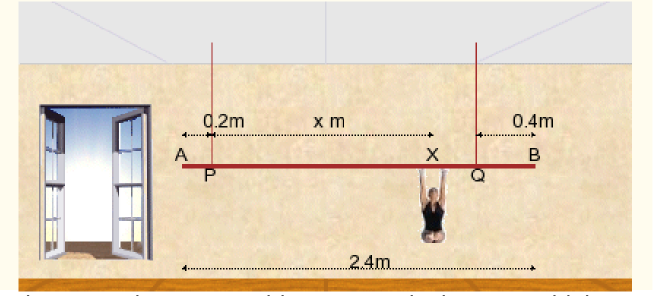
(a) the magnitude of the normal reaction between the plank and the leg at Q and the magnitude of the normal reaction between the plank and the leg at R.

Beatrice stays sitting at P but Arthur now moves and sits on the plank at the point X. Given that the plank remains horizontal and in equilibrium, and that the magnitude of the normal reaction between the plank and the leg at Q is now twice the magnitude of the normal reaction between the plank and the leg at R,

(b) find the distance QX.

Q209 - ID: 6977

[12 marks, 14 minutes]



A beam AB is supported by two vertical ropes, which are attached to the beam at points P and Q, where $AP = 0.2\,m$ and $BQ = 0.4\,m$. The beam is modelled as a uniform rod, of length 2.4 m and mass 24 kg. The ropes are modelled as light inextensible strings. A gymnast of mass 54 kg hangs on the beam between P and Q. The gymnast is modelled as a particle attached to the beam at the point X, where $PX = x\,m$, $0 < x < 1.6$ as shown. The beam rests in equilibrium in a horizontal position.

(a) Show that the tension in the rope attached to the beam at P is $(633.733 - 294x)\,N$.

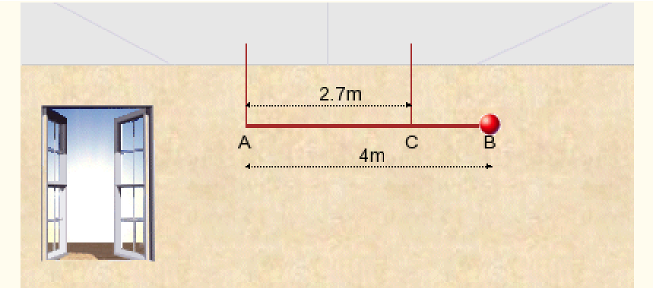
(b) Find, in terms of x, the tension in the rope attached to the beam at Q.

(c) Hence find, justifying your answer carefully, the range of values of the tension which could occur in each rope.

(d) Given that the tension in the rope attached at Q is 3 times the tension in the rope attached at P, find the value of x.

Q210 - ID: 7272

[10 marks, 12 minutes]



A pole AB has length 4 m and weight W N. The pole is held in equilibrium in a horizontal position by two vertical ropes attached to the pole at the points A and C where AC = 2.7 m, as shown. A load of weight 19 N is attached to the rod at B. The beam is modelled as a uniform rod, the ropes as light inextensible strings and the load as a particle.

(a) Show that the tension in the rope attached to the pole at C is $\left(\frac{20}{27}W + \frac{760}{27}\right)N$.

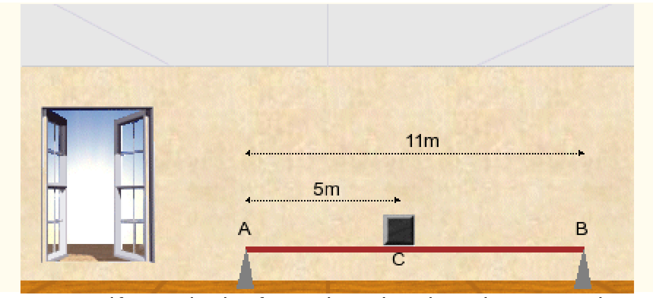
(b) Find, in terms of W, the tension in the rope attached to the pole at A.

Given that the tension in the rope attached to the pole at C is 5 times the tension in the rope attached to the pole at A,

(c) find the value of W.

Q211 - ID: 848

[7 marks, 8 minutes]



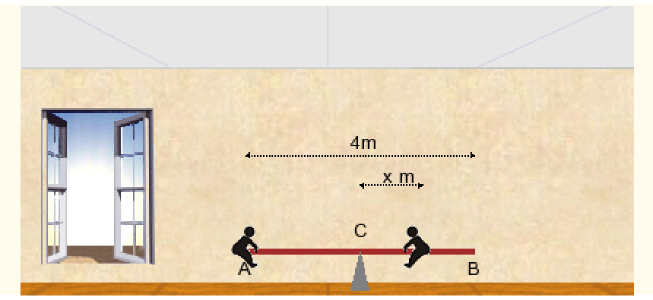
A non-uniform plank of wood AB has length 11 m and mass 120 kg. The plank is smoothly supported at its two ends A and B , with A and B at the same horizontal level. An object of mass 50 kg is put on the plank at the point C , where $AC = 5\,m$, as shown above. The plank is in equilibrium and the magnitudes of the reactions on the plank at A and B are equal. The plank is modelled as a non-uniform rod and the object as a particle. Find

(a) the magnitude of the reaction, R, on the plank at B.

(b) the distance, x, of the centre of mass of the plank from A.

Q212 - ID: 922

[8 marks, 10 minutes]



A seesaw consists of a beam AB of length $4m$ which is supported by a smooth pivot at its centre C. Janet has mass $22kg$ and sits on the end A. John has mass $40kg$ and sits at a distance x metres from C. The beam is initially modelled as a uniform rod. Using this model,

(a) find the value of x for which the seesaw can rest in equilibrium in a horizontal position.

(b) State what is implied by the modelling assumption that the beam is uniform.

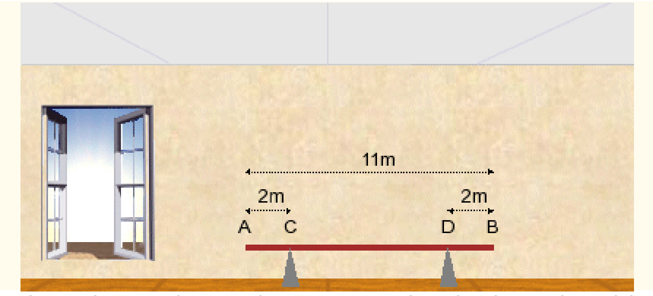
John realises that the beam is not uniform as he finds he must sit at a distance $1.4m$ from C for the seesaw to rest horizontally in equilibrium.

The beam is now modelled as a non uniform rod of mass $20kg$.

(c) Using this model, find the distance of the centre of mass of the beam from C.

Q213 - ID: 414

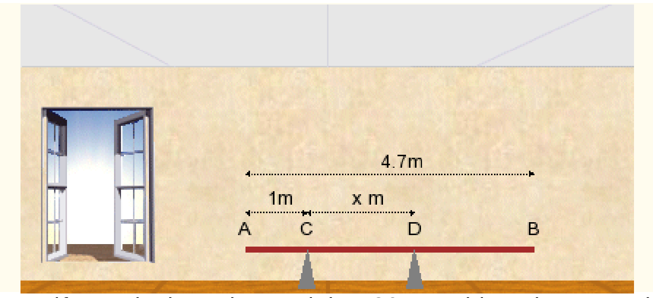
[12 marks, 14 minutes]



A large log AB is 11*m* long. It rests in a horizontal position on two smooth supports C and D, where *AC* = 2*m* and BD=2m, as shown above. An estimate of the weight of the log is needed, but the log is too heavy off both supports. When a force of magnitude 1200*N* is applied vertically upward to the log at A, the log is about to tilt about D.
(a) State the value of the reaction on the log at C for this case.
(b) Modelling the log as a uniform rod, estimate the weight of the log.
The force at A is removed and a force acting vertically upward is applied at B. The log is about to tilt about C when this force has magnitude 800*N*.
Modelling the log as a non-uniform rod, with the distance of the centre of mass of the log from C as *x* metres, find
(c) a new estimate for the weight of the log,
(d) the value of *x*.

Q214 - ID: 703

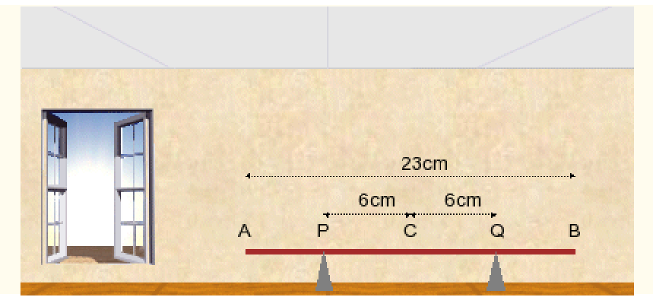
[10 marks, 12 minutes]



A uniform plank AB has weight 130 *N* and length 4.7 *m*. The plank rests horizontally in equilibrium on two smooth supports *C* and *D*, where *AC* = 1 *m* and *CD* = *x m*, as shown above.
The reaction of the support on the plank at *D* has magnitude 100*N*.
Modelling the plank as a rod,
(a) show that *x* = 1.755.
A rock is now placed at *B* and the plank is on the point of tilting about *D*. Modelling the rock as a particle, find
(b) the weight of the rock,
(c) the magnitude of the reaction of the support on the plank at *D*.
(d) State how you have used the model of the rock as a particle.

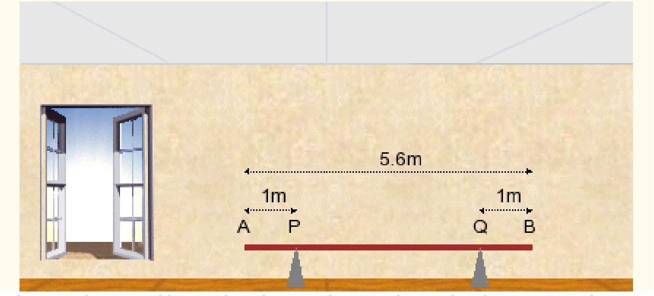
Q215 - ID: 7395

[5 marks, 6 minutes]



A uniform rod AB, of length $23\,cm$ and weight $4\,N$, is supported by two smooth supports at P and Q, one on each side of its centre C, with $PC = CQ = 6\,cm$, as shown in the diagram. A body, of weight $8\,N$, is placed on the rod at a point which is $x\,cm$ from the centre C of the rod.
Find the greatest value of x if equilibrium is maintained.

Q216 - ID: 7398 *[8 marks, 10 minutes]*



Shown is a uniform horizontal wooden plank AB resting on two smooth supports at P and Q. The plank has mass m kg and length 5.6 metres. $AP = QB = 1\,m$. A man of mass 82 kg stands on the plank 0.3 m from B. The reaction at Q is 1018 N.

(a) By taking moments about P, show that $m = 11.866$.

The man then walks towards B.

(bi) Find the reaction at Q at the instant that the plank starts to tilt.

Q217 - ID: 660 *[13 marks, 16 minutes]*

A coastguard station O monitors the movements of ships in a channel. At noon, the station radar records two ships moving with constant speed. Ship A is at the point with position vector $(-8\underline{i} + 10\underline{j})$ km relative to O and has velocity $(4\underline{i} + 3\underline{j})$ km/h.

Ship B is at the point with position vector $(2\underline{i} + 5\underline{j})$ km and has velocity $(-4\underline{i} + 7\underline{j})$ km/h, where $\underline{i}$ and $\underline{j}$ are unit vectors directed due east and due north respectively.

(a) Given that the two ships maintain these velocities, show that they collide.

The coast guard radios ship A and orders it to reduce its speed to move with velocity $(2\underline{i} + 2\underline{j})$ km/h.

(b) Find an expression for the vector $\overrightarrow{AB}$ at time t hours after noon.

(c) Find the the distance between A and B at 1400 hours.

(d) Find the time at which B will be due north of A.

Q218 - ID: 421 *[15 marks, 18 minutes]*

Two cars A and B are moving on straight horizontal roads with constant velocities. The velocity of A is 20 m/s due east, and the velocity of B is $(10\underline{i} + 6\underline{j})$ m/s, where $\underline{i}$ and $\underline{j}$ are unit vectors directed due east and due north respectively.

Initially A is at the fixed origin O , and the position vector of B is $200\underline{i}$ m relative to O . At time t seconds, the position vectors of A and B are r metres and s metres respectively.

(a) Find expressions for r and s in terms of t.

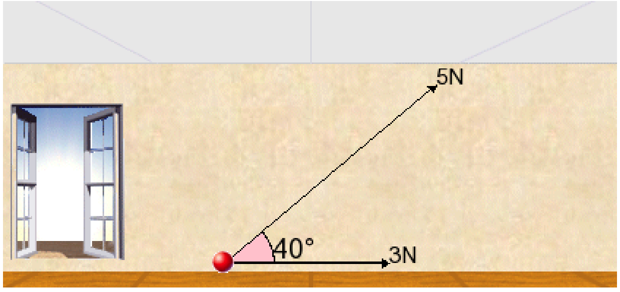
(b) Hence write down an expression for $\overrightarrow{AB}$ in terms of t.

(c) Find the time when the bearing of B from A is 045.

(d) Find the time when cars are again 200m apart.

Q219 - ID: 949

[5 marks, 6 minutes]



Two forces, of magnitudes 5 *N* and 3 *N*, act on a particle in the directions shown in the diagram.
Calculate the magnitude of the resultant force on the particle and the angle between this resultant force and the horizontal force of magnitude 3 *N*.

M1 full exam questions - Mark Scheme

A1 - ID: 690 *[11 marks, 13 minutes]*

(a) $t = 0.5 \Rightarrow (25\underline{i} + 45\underline{j}) + 0.5(a\underline{i} + b\underline{j}) = 35\underline{i} - 30\underline{j}$ | $M1$

$\Rightarrow 25 + 0.5a = 35 \Rightarrow a = 20$

$\Rightarrow 45 + 0.5b = -30 \Rightarrow b = -150$

$\Rightarrow$ velocity $= 20\underline{i} - 150\underline{j}$. | $A1$

(b) $p = (25\underline{i} + 45\underline{j}) + (20\underline{i} - 150\underline{j})t$ | $M1A1$

(c) vel. of Q = $c(4\underline{i} - 3\underline{j})$

$\Rightarrow 90 = \sqrt{(16+9)c^2} \Rightarrow c = 18$ | $M1A1$

$\Rightarrow q = 18(4\underline{i} - 3\underline{j})t$ | $A1$

(d) $t = 3 \Rightarrow p = 85\underline{i} + -405\underline{j}$

$\Rightarrow q = 216\underline{i} - 162\underline{j}$

$\Rightarrow PQ = 131\underline{i} + 243\underline{j}$ | $M1A1$

$\Rightarrow |PQ| = \sqrt{131^2 + 243^2} = 276\,km$ | $M1A1$

A2 - ID: 505 *[8 marks, 10 minutes]*

(a) $p = 11t\underline{j}$ | $B1$

$q = (4\underline{i} + 12\underline{j}) + t(-9\underline{i} + 7\underline{j})$ | $M1A1$

(b) $p = 44\underline{j}$

$q = (-32\underline{i} + 40\underline{j})$ | $M1A1$

$PQ = \sqrt{-32^2 + (40-44)^2}$

$= 32.249$ km | $A1$

(c) Q due north $\Rightarrow$ $\underline{i}$ component is zero | $M1$

$\Rightarrow 4 - 9t = 0$

$\Rightarrow t = 0.444$ hours | $A1$

A3 - ID: 7283 [16 marks, 19 minutes]

(a) Speed $= \sqrt{1+6^2} = 6.08\,ms^{-1}$ |$M1A1$

(b) $\theta = tan^{-1}\frac{6}{-1} = -80.5$ |$M1A1$

$\Rightarrow$ bearing = 351 |$A1$

(c) pos. vector for A $= (4i - 12.5j) + t(-i + 6j)$

pos. vector for B $= (-25i + 2j) + t(3i + 4j)$ |$B1$

equate i components $\Rightarrow 4 - t = -25 + 3t$

$\Rightarrow t = 7.25$ |$M1A1$

j component for A $= 31$

j component for B $= 31$

$\Rightarrow$ same so meet when t=7.25 |$M1$

$\Rightarrow$ position vector: $-3.25i + 31j$ |$A1$

(d) Velocity of B $= \frac{10}{5}(3i + 4j)$ |$B1$

pos. vec for B at $t = 7$ $= (-25i + 2j) + \frac{70}{5}(3i + 4j)$

$= 17i + 58j$ |$M1A1$

$\Rightarrow \vec{BP} = 20.3i + 27j$ |$M1$

$\Rightarrow$ distance $= \sqrt{20.3^2 + 27^2} = 33.8\,m$ |$M1A1$

A4 - ID: 7297 [15 marks, 18 minutes]

(a) Speed $= \sqrt{-2.5^2 + 6^2} = 6.5\,Kmh^{-1}$ |$M1A1$

(b) $\theta = tan^{-1}\frac{6}{-2.5} = -67.4$ |$M1$

$\Rightarrow$ bearing = 337 |$A1$

(c) pos. vector for R $= (12i + 7j) + 3(-2.5 + 6j) = 4.5i + 25j$ |$M1A1$

(d) at 1400 $\Rightarrow s = 7i + 19j$ |$M1A1$

t hours after 1400 $\Rightarrow s = 7i + (19 + 4t)j$ |$M1A1$

(e) Due east $\Rightarrow 19 + 4t = 25$

$\Rightarrow t = 1.5 \Rightarrow$ time = 1530 |$M1A1$

(f) At 1600 $\Rightarrow s = 7i + 27j$ |$M1$

$\Rightarrow s - r = 2.5i + 2j$ |$M1$

$\Rightarrow$ distance $= \sqrt{2.5^2 + 2^2} = 3.2\,km$ |$A1$

A5 - ID: 7282 [14 marks, 17 minutes]

(a) Velocity $= \dfrac{(9i + 10j) - (4i - 5j)}{2.5}$ | $M1A1$

$= (2i + 6j)$ | $A1$

(b) $b = (4i - 5j) + t(2i + 6j)$ | $M1A2$

(c) equate i components $\Rightarrow 4 + 2t = -8 + 6t$ | $M1A1$

$\Rightarrow t = 3$ | $A1$

equate j components $\Rightarrow -5 + 6t = 19 + t\lambda$

$\Rightarrow \lambda = -2$ | $M1A1$

(d) speed of B $= \sqrt{(2)^2 + (6)^2}$

speed of C $= \sqrt{(6)^2 + (-2)^2}$ | $M1A1$

$\Rightarrow$ B and C have same speed | $A1$

A6 - ID: 7420 [5 marks, 6 minutes]

(a) $V = 145 \tan 26 = 70.7\,ms^{-1}$ | $M1A1$

(b) magnitude $= \sqrt{145^2 + 70.7^2}$ | $M1A1$

$= 161.3ms^{-1}$ | $A1$

A7 - ID: 7772 [9 marks, 11 minutes]

(a) *velocity* $= \sqrt{0.2^2 + 0.3^2} = 0.361\,ms^{-1}$ | $M1A1$

(b) *angle* $= \tan^{-1} \frac{0.3}{0.2} = 56.3°$ | $M1A2$

(c) *time* $= \frac{17}{0.3} = 56.7\,s$ | $M1A1$

(d) *distance* $= 0.361 \times 56.7 = 20.431\,m$ | $M1A1$

A8 - ID: 2888 [13 marks, 16 minutes]

(a) speed $= \sqrt{-5^2 + 5^2} = 7.07$ | $M1A1$

(b) direction $= \tan^{-1} \frac{5}{-5} = 315$ | $M2A1$

(c) $t = 3 \Rightarrow$ P is at $(6\underline{i} - 9\underline{j}) + 3(-5\underline{i} + 5\underline{j}) = (-9\underline{i} + 6\underline{j})$ | $M1A1$

$t = 9 \Rightarrow (-9\underline{i} + 6\underline{j}) + 6(u\underline{i} + v\underline{j}) = 0$ | $M1$

$\Rightarrow u = 1.5, v = -1$ | $M1A1$

(d) at time $t \Rightarrow (-9\underline{i} + 6\underline{j}) + t(1.5\underline{i} + -1\underline{j}) = (6\underline{i} + ...)$ | $M1$

$\Rightarrow t = 10$ | $M1$

$\Rightarrow$ total time $= 13\,s$ | $M1$

A9 - ID: 7302 *[4 marks, 5 minutes]*

(a) $9^2 = 8^2 + U^2 \Rightarrow U = \sqrt{81 - 64} = 4.1\,ms^{-1}$ M1A1

(b) $\cos\theta = \frac{8}{9}$

$\Rightarrow \theta = 27$

$\Rightarrow$ bearing = 027° M1A1

A10 - ID: 7311 *[8 marks, 10 minutes]*

(a) Aeroplane = $0i + 193j$

Air = $-59\cos 45i + 59\sin 45j$

resultant = $-59\cos 45i + (193 + 59\sin 45j)$

= $-41.719i + 234.719j$ M1A1

magnitude = $\sqrt{(-41.719)^2 + 234.719^2} = 238ms^{-1}$ M1A1

(b) angle = $\tan^{-1}\frac{234.719}{-41.719} = -79.9°$ M1A1

bearing = 350 M1A1

A11 - ID: 6978 *[13 marks, 16 minutes]*

(a) $|v| = \sqrt{1.2^2 + 0.8^2} = 1.442\,ms^{-1}$ M1A1

(b) $r_H = 90j + t(1.2i - 0.8j)\ m$ M1A1

(c) $r_K = (7i + 48j) + t(0.75i + 1.9j)\ m$ M1

$= (7 + 0.75t)i + (48 + 1.9t)j\,m$ A1

$\Rightarrow \vec{HK} = (7 + 0.75t)i + (48 + 1.9t)j - 90j - t(1.2i - 0.8j)$

$\Rightarrow \vec{HK} = (7 - 0.45t)i + (-42 + 2.7t)j\,m$ M1A1

(d) $\vec{HK} = 0 \Rightarrow 7 - 0.45t = 0$

$\Rightarrow t = 15.556$ A1

$\Rightarrow -42 + 2.7t = 0$

$\Rightarrow t = 15.556 \Rightarrow$ same time M1A1

$t = 15.556 \Rightarrow r_H = 18.667i + 77.5552j\,m$ M1A1

A12 - ID: 7327 *[8 marks, 10 minutes]*

(a) Boat = $-2i + 0j$

Water = $3\cos 45i + 3\sin 45j$

resultant = $(-2 + 3\cos 45)i + 3\sin 45j$ M1A1

magnitude = $\sqrt{((-2 + 3\cos 45)^2 + (3\sin 45j)^2} = 2.12ms^{-1}$ M1A1

(b) angle = $\tan^{-1}\frac{3\sin 45}{-2+3\cos 45} = 86.7°$ M1A1

bearing = 183 M1A1

A13 - ID: 7766 [6 marks, 7 minutes]

(a) $V = \frac{15}{5} = 3\,ms^{-1}$ |B1

(b) $V^2 = 3^2 + 1.1^2$ |M1A1

$\Rightarrow V = \sqrt{10.21} = 3.2\,ms^{-1}$ |A1

(c) $\tan\alpha = \frac{3}{1.1} = 69.9°$ |M1A1

A14 - ID: 7270 [14 marks, 17 minutes]

(a) distance travelled$= \sqrt{(23-11)^2 + (5--7)^2} = 16.971\,m$ |M1A1

$\Rightarrow$ speed $= 16.971 \div 4 = 4.2\,km/h$ |M1A1

(b) $\theta = \tan^{-1}\frac{5--7}{23-11} = 45$

$\Rightarrow$ bearing = 045° |M1A1

(c) $t = 0 \Rightarrow s = (3(0) + 11)i + (3(0) - 7)j = 11i - 7j$

$t = 4 \Rightarrow s = (3(4) + 11)i + (3(4) - 7)j = 23i + 5j$

$\Rightarrow$ vector s passes through two given positions |M1A1

(d) vector from S to L $= (3t - 9)i + (3t - 13)j$ |M1A1

$\Rightarrow (3T - 9)^2 + (3T - 13)^2 = 11^2$ |M1A1

$\Rightarrow 9T^2 - 54T + 81 + 9T^2 - 78T + 169 = 121$

$\Rightarrow 18T^2 - 132T + 129 = 0$

$\Rightarrow T = 6.2, 1.2$ |M1A1

A15 - ID: 481 [6 marks, 7 minutes]

(a) $\updownarrow \Rightarrow 2.5\,sin(180 - \theta) = 1$ |M1

$\Rightarrow sin(180 - \theta) = \frac{1}{2.5}$ |A1

$\Rightarrow 180 - \theta = 23.6$

$\Rightarrow \theta = 156.4$ |A1

(b) $\leftrightarrow \Rightarrow 2.5\,cos(180 - \theta) = c$ |M1

$\Rightarrow c = 2.5\,cos(23.6) = 2.29\,N$ |A2

A16 - ID: 3157 [9 marks, 11 minutes]

(a) resultant, $R = 16\cos 24\underline{i} - 16\sin 24\underline{j}$ |M1A1

$P + Q = R \Rightarrow Q = R - P = 16\cos 24\underline{i} - 16\sin 24\underline{j} - 13\underline{j}$

$\Rightarrow Q = 14.6167\underline{i} - 19.5078\underline{j}$ |M1A1

$\Rightarrow |Q| = \sqrt{14.6167^2 + 19.5078^2} = 24.4\,N$ |M1A1

(b) $\theta = \tan^{-1}\frac{19.5078}{14.6167} = 53.2°$ |M1A1

$\Rightarrow$ bearing = 143.2° |A1

A17 - ID: 2911 [5 marks, 6 minutes]

(a) Resolve $\leftrightarrow \Rightarrow P\cos 62 = 25$ | M1A1

$\Rightarrow P = 53.25\,N$ | A1

(b) Resolve $\updownarrow \Rightarrow 125 = P\sin 62 + Q$

$\Rightarrow Q = 125 - P\sin 62 = 77.98\,N$ | M1A1

A18 - ID: 4579 [6 marks, 7 minutes]

(a) x-direction $\Rightarrow 17 + -11 = 6\,N$ | B1

y-direction $\Rightarrow 6 + 4 = 10\,N$ | B1

(b) magnitude = $\sqrt{6^2 + 10^2} = 11.66\,N$ | M1A1

angle = $\tan^{-1}\frac{10}{6} = 59.04°$ | M1A1

A19 - ID: 7424 [6 marks, 7 minutes]

(a) $F = \sqrt{6^2 + 4^2}$ | M1A1

$= 7.21\,N$ | A1

(b) $\alpha = \tan^{-1}\frac{4}{6}$ | M1A1

$= 33.7°$ | A1

A20 - ID: 2906 [7 marks, 8 minutes]

(a) $\begin{pmatrix}5\\1\\4\end{pmatrix} + \begin{pmatrix}-8\\2\\3\end{pmatrix} = \begin{pmatrix}-3\\3\\7\end{pmatrix}$ | M1A1

magnitude $= \sqrt{-3^2 + 3^2 + 7^2} = \sqrt{67}\,N$ | M1A1

(b) $F + 2G + H = 0 \Rightarrow \begin{pmatrix}5\\1\\4\end{pmatrix} + \begin{pmatrix}-16\\4\\6\end{pmatrix} + H = 0$ | M1A1

$\Rightarrow H = \begin{pmatrix}11\\-5\\-10\end{pmatrix}$ | A1

A21 - ID: 3303 [9 marks, 11 minutes]

(a) $P = -14\cos 28i + 14\sin 28j$

$Q = Xi$

$\Rightarrow R = P + Q = (X - 14\cos 28)i + 14\sin 28j$ | M1A2

$\Rightarrow 14\sin 28 = M\sin 57$

$\Rightarrow M = \dfrac{14\sin 28}{\sin 57} = 7.8$ | M1A1

(b) $(X - 14\cos 28) = 7.8\cos 57$ | M1A1

$\Rightarrow X = 7.8\cos 57 + 14\cos 28 = 16.6\,N$ | M1A1

A22 - ID: 4577 *[8 marks, 10 minutes]*

(a) magnitude $= \sqrt{14^2 + 14^2} = 19.8$ |*M1A2*

$\tan\theta = \dfrac{14}{14}$ |*M1A1*

$\Rightarrow \theta = 45$ |*A1*

(b) magnitude $= 19.8$ |*B1*

bearing $= 45 + 180 = 225$ |*B1*

A23 - ID: 5458 *[5 marks, 6 minutes]*

(a) magnitude $= \sqrt{(5)^2 + (-7)^2} = \sqrt{25 + 49} = \sqrt{74}$

$= 8.602$ |*M1A1*

direction $= \tan^{-1} \frac{-7}{5} = -54.5$

$\Rightarrow$ bearing $= 144.5°$ |*M1A1*

(b) vector $= 30\underline{i} - 42\underline{j}$ |*B1*

A24 - ID: 7309 *[6 marks, 7 minutes]*

(a) resultant $= (0i + 13j) + (0i - 16j) + (6i + 0j) = 6i - 3j$ |*M1A1*

(b) magnitude $= \sqrt{6^2 + 3^2} = \sqrt{45}\,N$ |*M1A1*

(c) angle $= \tan^{-2} \frac{3}{6} = 26.6°$ |*M1A1*

A25 - ID: 7333 *[8 marks, 10 minutes]*

(a) Force P $= 0i + 14j$ |*M1*

Force Q $= 16\sin 37i + 16\cos 37j$ |*M1*

resultant $= 16\sin 37i + (14 + 16\cos 37j)$

$= 9.629i + 26.778j$ |*M1A1*

magnitude $= \sqrt{(9.629)^2 + 26.778^2} = 28.5\,ms^{-1}$ |*A1*

(b) angle $= \tan^{-1} \frac{9.629}{26.778} = 19.8°$ |*M1A1*

bearing $= 020°$ |*A1*

A26 - ID: 7394 *[8 marks, 10 minutes]*

Resolve in x-direction $X = 7 - 10\cos 26 = -1.988\,N$ |*M1A1*

Resolve in y-direction $Y = 9 - 10\sin 26 = 4.616\,N$ |*M1A1*

magnitude $= \sqrt{-1.988^2 + 4.616^2}$

$= 5.03\,N$ |*M1A1*

angle $= \tan^{-1} \frac{4.616}{-1.988} = -66.7°$ |*M1A1*

A27 - ID: 7408 *[11 marks, 13 minutes]*

(a) x-component = $P + 4\sin 62 - 7\sin 46$ |$M2A2$

y-component = $4\cos 62 - 7\cos 46$ |$M1A1$

$45° \Rightarrow 7\cos 46 - 4\cos 62 = P + 4\sin 62 - 7\sin 46$ |$M1A1$

$\Rightarrow P = 7\cos 46 - 4\cos 62 - 4\sin 62 + 7\sin 46 = 4.49$ |$A1$

(b) magnitude = $\sqrt{(P + 4\sin 62 - 7\sin 46)^2 + (4\cos 62 - 7\cos 46)^2}$

$= 4.22\, N$ |$M1A1$

A28 - ID: 6972 *[6 marks, 7 minutes]*

(a) $\tan\theta = \dfrac{p}{5p}$ |$M1$

$\Rightarrow \theta = 11.3°$ |$A1$

(b) $R = (i - 3j) + (pi + 5pj) = (1 + p)i + (-3 + 5p)j$ |$M1A1$

$\Rightarrow (-3 + 5p) = 0$ |$M1$

$\Rightarrow p = \dfrac{3}{5}$ |$A1$

A29 - ID: 7341 *[8 marks, 10 minutes]*

(a) Resultant in x-direction = $3\cos 27$ |$B1$

Resultant in y-direction = $3\sin 27$ |$B1$

(b) Resultant in x-direction = $6 - 3\cos 27$

Resultant in y-direction = $3 - 3\sin 27$ |$M1A1$

magnitude = $\sqrt{(6 - 3\cos 27)^2 + (3 - 3\sin 27)^2}$

$= 3.71 ms^{-1}$ |$A1$

angle = $\tan^{-1} \frac{3 - 3\sin 27}{6 - 3\cos 27}$ |$M1A1$

$= 26.2°$ |$A1$

A30 - ID: 1931 *[7 marks, 8 minutes]*

(a) $v = u + at \Rightarrow v_B = 10 + 5 \times 8 = 50 ms^{-1}$ |$M1A1$

(b) $OA : v^2 = u^2 + 2as \Rightarrow 10^2 = 0^2 + 2 \times 6 \times OA$

$\Rightarrow OA = \frac{10^2}{12} = 8.333m$ |$M1A1$

AB: $s = ut + \frac{1}{2}at^2 \rightarrow s = 10 \times 8 + \frac{1}{2}5 \times 64$

$\Rightarrow s = 240$ |$M1A1$

$OB = OA + AB \rightarrow OB = 8.333 + 240$

$\Rightarrow OB = 248.333m$ |$A1$

A31 - ID: 1935 [7 marks, 8 minutes]

(a) $v^2 = u^2 + 2as \Rightarrow 40^2 = 14^2 + 2.a.110$ | $M1A1$

$\Rightarrow a = \frac{40^2-14^2}{2.110} = 6.382m/s^2$ | $A1$

(b) $t = \frac{v-u}{a} \Rightarrow t = \frac{40-14}{6.382}$ | $M1$

$\Rightarrow t = 4.074s$ | $A1$

(c) $v^2 = u^2 + 2as \Rightarrow v^2 = 14^2 + 2.6.382.55$ | $M1$

$\Rightarrow v^2 = 898$

$\Rightarrow v = 29.967m/s$ | $A1$

A32 - ID: 1936 [8 marks, 10 minutes]

(a) $v = u + at \Rightarrow 66 = 13 + 4a$ | $M1$

$\Rightarrow a = 13.25\,ms^{-2}$ | $A1$

(b) $s = ut + \frac{1}{2}at^2 \Rightarrow OA = 52 + \frac{1}{2}212$ | $M1A1$

$OA = 158\,m$ | $A1$

(c) $v^2 = u^2 + 2as \Rightarrow v^2 = 169 + 26.5 \times 79$ | $M1A1$

$\Rightarrow v^2 = 2262.5$

$\Rightarrow v = 47.6\,ms^{-1}$ | $A1$

A33 - ID: 1937 [6 marks, 7 minutes]

(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 54 = 3 \times 6 + \frac{1}{2} \times a \times 36$ | $M1A1$

$\Rightarrow 36 = 18a$

$\Rightarrow a = 2\,ms^{-1}$ | $A1$

(b) $v^2 = u^2 + 2as \Rightarrow 1089 = 9 + 2 \times 2 \times s$ | $M1A1$

$\Rightarrow 1080 = 4s$

$\Rightarrow s = 270\,m$ | $A1$

A34 - ID: 1938 [5 marks, 6 minutes]

(a) $1200 = \frac{1}{2}(0 + 15)T + (15 \times 5T) + \frac{1}{2}(15 + 0) \times 50$ | $M1$

$= 7.5T + 75T + 375$

$\Rightarrow T = \frac{825}{82.5} = 10s$ | $M1A1$

(b) $v = u + at \Rightarrow 15 = 0 + 10a$

$\Rightarrow a = \frac{15}{10} = 1.5\,ms^{-2}$ | $M1A1$

A35 - ID: 722 [6 marks, 7 minutes]

(a) $u = 1ms^{-1}, v = 75ms^{-1}, t = 14$

$v = u + at \Rightarrow 75 = 1 + 14a$

$\Rightarrow a = 5.29ms^{-2}$ |M1A1

(b) $s = ut + \frac{1}{2}at^2 \Rightarrow s = 1 \times 14 + \frac{1}{2}5.29 \times 14^2$ |M1A1

$\Rightarrow s = 532\,m$ |A1

$\Rightarrow BC = 1600 - 532 = 1068\,m$ |B1

A36 - ID: 789 [10 marks, 12 minutes]

(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 50 = 20 \times 2 + \frac{1}{2}a \times 2^2$ |M1A1

$\Rightarrow 50 = 40 + 2a$

$\Rightarrow a = 5ms^{-2}$ |A1

(b) $v^2 = u^2 + 2as \Rightarrow v^2 = 20^2 + 2 \times 5 \times 100$ |M1A1

$\Rightarrow v^2 = 402.5$

$\Rightarrow v = 37.42\,ms^{-1}$ |A1

(c) $s = \frac{1}{2}(u + v)t \Rightarrow 100 = \frac{1}{2}(20 + 37.42)t$ |M1A1

$\Rightarrow t = 3.48$

$\Rightarrow$ time $= 1.48\,s$ |M1A1

A37 - ID: 7421 [12 marks, 14 minutes]

(a) Velocity $= 7i\,ms^{-1}$ |B1

(b) $v = 7i + t(-0.5i + 0.3j)$ |M1A1

(c) due north $\Rightarrow 7 + -0.5t = 0$ |M1A1

$\Rightarrow t = 14\,s$ |A1

(d) $s = ut + \frac{1}{2}at^2 \Rightarrow r = 7(14)i + \frac{1}{2}(-0.5i + 0.3j)(14)^2$ |M1A1

$\Rightarrow r = 49i + 29.4j$ |A1

bearing $= \tan^{-1}\frac{49}{29.4}$ |M1A1

$= 59°$ |A1

A38 - ID: 7769 [6 marks, 7 minutes]

(a) $v^2 = u^2 + 2as \Rightarrow 16^2 = 11^2 + 2a \times 20$ |M1A1

$\Rightarrow a = 3.38\,ms^{-2}$ |A1

(b) $v = u + at \Rightarrow 16 = 11 + 3.38t$ |M1A1

$\Rightarrow t = 1.48\,s$ |A1

A39 - ID: 7774 *[12 marks, 14 minutes]*

(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 80i = 5(6i - 3j) + \frac{1}{2}a \times 5^2$ |M1A1

$\Rightarrow a = \dfrac{50i + 15j}{12.5} = (4i + 1.2j)\ ms^{-2}$ |A1

(b) $s = ut + \dfrac{1}{2}at^2 \Rightarrow r = 4(6i - 3j) + \dfrac{1}{2}(4i + 1.2j) \times 4^2$ |M1A1

$\Rightarrow r = 56i - 2.4j$ |A1

(c) $v = u + at \Rightarrow v = (6i - 3j) + (4i + 1.2j)t$

$\Rightarrow v = (6 + 4t)i + (1.2t - 3)j$ |M1A1

$\Rightarrow 1.2t - 3 = 0$ |M1

$\Rightarrow t = 2.5$ |A1

$\Rightarrow r = 2.5(6i - 3j) + \dfrac{1}{2}(4i + 1.2j) \times 2.5^2 = 27.5i - 3.75j$ |M1A1

A40 - ID: 5461 *[7 marks, 8 minutes]*

(a) P : distance $= 0 + \frac{1}{2}0.3t^2$ |B1

Q : distance $= 5.4t + 0$ |B1

(b) P catches Q $\Rightarrow \frac{1}{2}0.3t^2 = 5.4t + 69$ |M1A1

$\Rightarrow t^2 - 36t - 460 = 0$ |M1

$\Rightarrow (t - 46)(t + 10) = 0$

$\Rightarrow t = 46, -10$ |A1

$\Rightarrow$ distance $= 317.4$ m |A1

A41 - ID: 7307 *[14 marks, 17 minutes]*

(a) $v = u + at \Rightarrow 2i + 0j = 0i + 4j + 16a$ |M1A1

$\Rightarrow a = \frac{2i - 4j}{16} = 0.125i - 0.25j$ |M1A1

(b) $s = ut + \frac{1}{2}at^2 = 16(0i + 4j) + \frac{256}{2}(0.125i - 0.25j)$ |M1A1

$= 16i - -32j$ |A1

(c) $v = 0i + 4j + t(0.125i - 0.25j)$

$= 0.125ti + (4 - 0.25t)j$ |M1A1

south-east $\Rightarrow 4 - 0.25t = -0.125t$ |M1A1

$\Rightarrow 4 = 0.125t \Rightarrow t = 32$ |A1

(d) $t = 32 \Rightarrow v = 0i + 4j + 32(0.125i - 0.25j)$

$= 4i - 4j$ |M1A1

A42 - ID: 7313 *[13 marks, 16 minutes]*

(a) $v = 10i + (-0.2i + 0.7j)t$ |*M*1*A*1

(b) $v = (10 - 0.2t)i + 0.7tj$ |*M*1

due north $\Rightarrow 10 - 0.2t = 0$

$\Rightarrow t = 50\,s$ |*M*1*A*1

(c) $s = ut + \frac{1}{2}at^2 \Rightarrow r = 10it + \frac{1}{2}(-0.2i + 0.7j)t^2$ |*M*1*A*1

(d) $t = 100 \Rightarrow r = 1000i + 5000(-0.2i + 0.7j) = 0i + 3500j$ |*M*1*A*1

$\Rightarrow$ due north |*A*1

(e) $v = 10i + 100(-0.2i + 0.7j) = -10i + 70j$ |*M*1*A*1

$\Rightarrow$ speed $= \sqrt{-10^2 + 70^2} = 70.7\,ms^{-1}$ |*A*1

A43 - ID: 5039 *[5 marks, 6 minutes]*

(a) $v = u + at \Rightarrow (-5\underline{i} + 4\underline{j}) = u + 2(4\underline{i} - 4\underline{j})$ |*M*1*A*1

$\Rightarrow -5\underline{i} + 4\underline{j} = u + 8\underline{i} - 8\underline{j}$

$\Rightarrow u = -5\underline{i} + 4\underline{j} - 8\underline{i} + 8\underline{j} = -13\underline{i} + 12\underline{j}$ |*M*1*A*1

$\Rightarrow$ speed $= \sqrt{169 + 144} = \sqrt{313}\,ms^{-1}$ |*A*1

A44 - ID: 6971 *[7 marks, 8 minutes]*

$48 = 2u + \frac{1}{2}a2^2 \Rightarrow 48 = 2u + 2a$ |*M*1*A*1

$168 = 6u + \frac{1}{2}a6^2 \Rightarrow 168 = 6u + 18a$ |*M*1*A*1

$\Rightarrow 24 = 12a$

$\Rightarrow a = 2$ |*M*1*A*1

$\Rightarrow u = 22$ |*A*1

A45 - ID: 7352 *[8 marks, 10 minutes]*

(a) $t = 0 \Rightarrow v = 4\,ms^{-1}$ |*B*1

acceleration $= 2\,ms^{-2}$ |*B*1

(b) $t = 3 \Rightarrow v = 10\,ms^{-1}$ |*B*1

distance $= \frac{4+10}{2} \times 3 = 21\,m$ |*M*1*A*1

(c) $3 \leq t \leq 14 \Rightarrow s = ut + \frac{1}{2}at^2 = 10(11) + \frac{1}{2}3(11)^2 = 291.5$ |*M*1

$\Rightarrow$ total distance $= 21 + 291.5 = 312.5\,m$ |*M*1*A*1

A46 - ID: 7767 *[12 marks, 14 minutes]*

(a) $v = (-3i + 2j) + 10(0.2i + 0.3j)\ ms^{-1}$ |M1A1

$= (-1i + 5j)\ ms^{-1}$ |A1

(b) $north \Rightarrow -3 + 0.2t = 0$ |M1A1

$\Rightarrow t = 15s$ |A1

$v = u + at \Rightarrow v = (2 + 0.3 \times 15)j = 6.5j$ |A1

(c) position $= ut + \frac{1}{2}at^2 + (11i + 6j)$

$= (-3i + 2j) \times 10 + \frac{1}{2}(0.2i + 0.3j) \times 10^2 + (11i + 6j)$ |M1A1

$= -9i + 41j$ |A1

(d) average velocity $= \dfrac{(-9i + 41j) - (11i + 6j)}{10} = -2i + 3.5j$ |M1A1

A47 - ID: 1933 *[9 marks, 11 minutes]*

(a) accel. time : 14

decel. time : 14 |M1A1

distance = total area

$= \frac{1}{2} \times 42 \times 14 + (42 \times 80) + \frac{1}{2} \times 42 \times 14$ |M1A1

$= 3948$ |A1

(b) comment : no period of constant velocity |A1

(c) max speed $= V \Rightarrow \frac{1}{2} \times 190 \times V = 3948$ |M1A1

$\Rightarrow V = 41.558$ |A1

A48 - ID: 1934 *[9 marks, 11 minutes]*

(a) distance = total area

$= \frac{1}{2} \times (27 + 16) \times 4 + (4 \times 16)$ |M1A2

$= 150m.$ |A1

(b) straight line $\Rightarrow$ constant deceleration |M1

F=Ma $\Rightarrow$ F is constant |A1

(c) deceleration $= \frac{27-16}{4}$ |M1

Force $= 1060 \times \frac{27-16}{4}$ |M1

$= 2915N$ |A1

A49 - ID: 448 *[9 marks, 11 minutes]*

At T : both trains travelled same distance | $M1$

$a = 8, b = 40, c = 56$ | $M1A2$

$\Rightarrow \frac{1}{2}(T + (T - 8)) \times 25 = \frac{1}{2}((T - 40) + (T - 56)) \times 50$ | $M2A1$

$\Rightarrow (T + (T - 8)) \times 25 = ((T - 40) + (T - 56)) \times 50$

$\Rightarrow 2T - 8 = 4T - 192$

$\Rightarrow 192 - 8 = 2T$

$\Rightarrow 184 = 2T \Rightarrow T = 92s$ | $M1A1$

A50 - ID: 7285 *[6 marks, 7 minutes]*

(a) motion = constant acceleration | $B1$

(b) motion = constant speed | $B1$

(c) distance $= \frac{1}{2}(3 + 5) \times 2 + 5 \times 3$ | $B1M1A1$

$= 23m$ | $A1$

A51 - ID: 2912 *[5 marks, 6 minutes]*

(a) 1st stage $= \frac{1}{2}(12 + 31) \times 8 = 172m$

2nd stage $= \frac{1}{2}(31 + 42) \times 16 = 584m$

3rd stage $= 42 \times 24 = 1008m$ | $M1A1$

total distance $= 1764m$ | $A1$

(b) $BT = 1911 - 1764 = 147$

$\Rightarrow \frac{1}{2}T \times 42 = 147$

$\Rightarrow T = 7s$ | $M1A1$

A52 - ID: 7277 *[8 marks, 10 minutes]*

(a) 1st stage $= 20 \times 9 = 180m$

2nd stage $= \frac{1}{2}12(20 + V) = 120 + 6V$

3rd stage $= 11V$

$\Rightarrow 180 + 120 + 6V + 11V = 453$ | $M1A2$

$\Rightarrow 17V = 153$

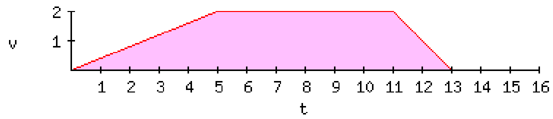
$\Rightarrow V = 9ms^{-1}$ | $M1A1$

(b) deceleration $= \dfrac{20 - 9}{12}$ | $M1A1$

$= 0.9ms^{-2}$ | $A1$

A53 - ID: 7423

[10 marks, 12 minutes]



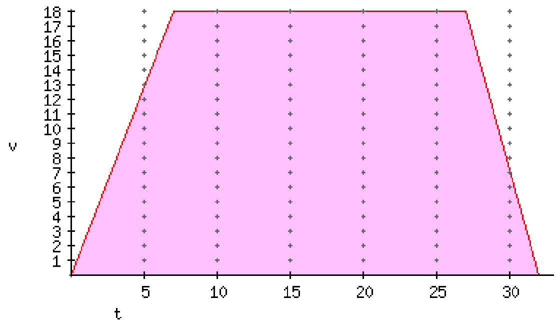
(a)	diagram : start and finish at rest	$B1$
	correct shape	$B1$
	correct t values	$B1$
	correct v values	$B1$
(b)	area $= 5 + 12 + 2 = 19\,m$	$M1A1$
(c)	max acceleration $= 0.4\,ms^{-2}$	$M1A1$
	$force = ma \Rightarrow T - 350g = 350 \times 0.4$	
	$\Rightarrow T = 3570\,N$	$M1A1$

A54 - ID: 2885

[8 marks, 10 minutes]

(a)	1st stage $= 123 \Rightarrow \frac{1}{2}(12 + 5)t = 123$	
	$\Rightarrow t = 14.5\,s$	$M1A1$
	$\Rightarrow$ total time $= 14.5 + 19 + 25 = 58.5$	$A1$
(b)	2nd stage $= \frac{1}{2}(5 + V)19 = 47.5 + 9.5V$	
	3rd stage $= 25V$	$M1A1$
	total $= 2000 \Rightarrow 123 + 47.5 + 9.5V + 25V = 2000$	$M1A1$
	$\Rightarrow 34.5V = 1829.5$	
	$\Rightarrow V = 53\,ms^{-1}$	$A1$

A55 - ID: 2904 *[6 marks, 7 minutes]*



(a) velocity - time graph = see diagram | $B3$

(b) 1st area $= \frac{1}{2}7 \times 18 = 63\,m$

2nd area $= 20 \times 18 = 360\,m$

3rd area $= \frac{1}{2}5 \times 18 = 45\,m$ | $M1A1$

total distance $= 468\,m$ | $A1$

A56 - ID: 7308 *[7 marks, 8 minutes]*

(a) 1st stage $= \frac{1}{2}2 \times 3 = 3$

2nd stage $= 3 \times 3 = 9$

3rd stage $= \frac{1}{2}4 \times 3 = 6$

$\Rightarrow$ distance $= 18\,m$ | $M1A2$

(b) acceleration $= 3 \div 2 = 1.5\,ms^{-2}$ | $B1$

(c) $force = ma \Rightarrow 400 \times 1.5 = T - 400g$ | $M1A1$

$\Rightarrow T = 4520\,N$ | $A1$

A57 - ID: 7331 *[8 marks, 10 minutes]*

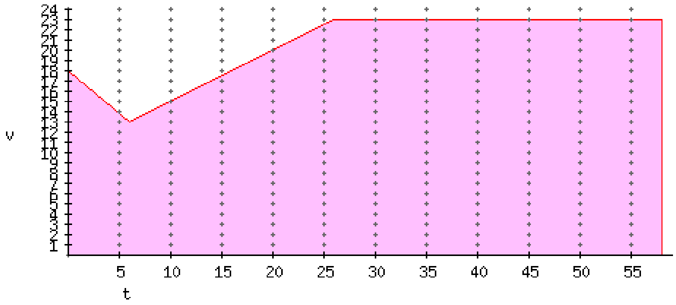
(a) initial acceleration $= 3 \div 5 = 0.6\,ms^{-2}$ | $M1A1$

(b) total distance $= 2 \times \frac{1}{2}10 \times 3 = 30\,m$ | $M2A1$

(c) $v = u + at \Rightarrow -3 + 0.6 \times 3 = -1.2\,ms^{-1}$ | $M1A2$

A58 - ID: 7387

[6 marks, 7 minutes]



(a) time $= \dfrac{23-13}{0.5} = 20\,s$ — $M1A1$

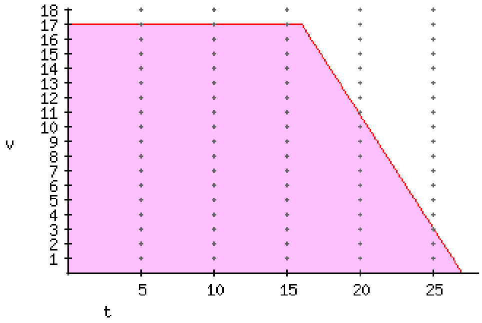
(b) velocity-time graph attempt — $M1$

Straight line joining (0, 18) to (6, 13) — $A1$

Straight line joining (6, 13) to (26, 23) — $A1$

Straight line joining (26, 23) to (58, 23) — $A1$

A59 - ID: 7402 [14 marks, 17 minutes]



(a) velocity - time graph: attempt |$M1A1$

(b) deceleration $= 17 \div 11 = 1.55\,ms^{-2}$ |$M1A1$

(c) distance $= 17T + 93.5$ |$M1A2$

(d) $s = ut + \frac{1}{2}at^2 = \frac{1}{2} \times \frac{6}{4} \times (T + 6)^2$ |$M1A1$

same distances for A & B $\Rightarrow 17T + 93.5 = \frac{6}{8}(T + 6)^2$ |$M1A1$

$\Rightarrow 17T + 93.5 = \frac{6}{8}(T^2 + 12T + 36)$

$\Rightarrow 136T + 748 = 6T^2 + 72T + 216$

$\Rightarrow 6T^2 - 64T - 532 = 0$

$\Rightarrow T = 16.16, -5.49$ |$M1A1$

$T = 16.16 \Rightarrow$ distance $= 17(16.16) + 93.5 = 368.22\,m$ |$A1$

A60 - ID: 7315 [10 marks, 12 minutes]

(a) velocity zero at: $t = 0, 10, 20\,s$ |$B2$

(b) distance $= \frac{1}{2}10 \times 7 = 35\,m$ |$M1A1$

(c) total distance travelled $= 35 + \frac{1}{2}10 \times 9 = 80\,m$ |$M2A2$

(d) distance $= 35 - \frac{1}{2}10 \times 9 = -10\,m$ |$M1A1$

A61 - ID: 7353 [4 marks, 5 minutes]

(a) $v = u + at = 6 + 4 \times 2 = 14\,ms^{-1}$ |$M1A1$

(b) $-6 = 14 + -10t \Rightarrow 10t = 20$

$\Rightarrow t = 2$

$\Rightarrow$ time $= 2 + 2 = 4\,s$ |$M1A1$

A62 - ID: 7269 [5 marks, 6 minutes]

1st stage = $\frac{1}{2}8 \times 10 = 40\,m$
2nd stage = $T \times 10 = 10T$
3rd stage = $\frac{1}{2}(75 - T) \times 10 = 5(75 - T)$ | $M1A1$
total distance = $470 \Rightarrow 470 = 40 + 10T + 5(75 - T)$ | $M1A1$
$\Rightarrow 470 = 40 + 10T + 375 - 5T$
$\Rightarrow 55 = 5T$
$\Rightarrow T = 11$ | $A1$

A63 - ID: 1939 [8 marks, 10 minutes]

(a) $v^2 = u^2 + 2as \Rightarrow v^2 = 2^2 + 2(-9.8)(-6)$ | $M1$
$\Rightarrow v^2 = 121.6 \Rightarrow v = \sqrt{121.6} = 11$ | $M1A1$
(b) $s = ut + \frac{1}{2}at^2 \Rightarrow -6 = 2t + \frac{1}{2}(-9.8)t^2$ | $M1$
$\Rightarrow 4.9t^2 - 2t - 6 = 0$
$\Rightarrow t = \frac{2+\sqrt{4+117.6}}{9.8} = 1.33$ secs | $M1A1$
(c) factors = air resistance, size of diver | $B2$

A64 - ID: 827 [6 marks, 7 minutes]

(a) distance after 3s $= ut + \frac{1}{2}at^2 = 11 \times 3 - \frac{1}{2} \times 9.8 \times 3^2$ | $M1A1$
$= -11.1 \Rightarrow h = 11.1m$ | $A1$
(b) $v = u + at = 11 - 9.8 \times 3$ | $M1A1$
$= -18.4 \Rightarrow v = 18.4ms^{-1}$ | $A1$

A65 - ID: 738 [10 marks, 12 minutes]

(a) $v^2 = u^2 + 2as \Rightarrow 0 = 17^2 + 2 \times -9.8 \times h$ | $M1A1$
$\Rightarrow h = 14.74\,m$ | $A1$
(b) $v^2 = u^2 + 2as \Rightarrow v^2 = 0 + 2 \times 9.8 \times 16.04$ | $M1A1$
$\Rightarrow v^2 = 314.384$
$\Rightarrow v = 17.73\,ms^{-1}$ | $A1$
(c) $v = u + at \Rightarrow -17.731 = 17 - 9.8t$ | $M1A2$
$\Rightarrow t = 3.54\,s$ | $A1$

A66 - ID: 7419 [5 marks, 6 minutes]

(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 317 = 0 + \frac{1}{2}a(66)^2$ | $M1A1$
$\Rightarrow a = \frac{634}{4356} = 0.146\,ms^{-2}$ | $A1$
(b) $v = u + at = 0 + 0.146 \times 66 = 9.61\,ms^{-1}$ | $M1A1$

A67 - ID: 2884 *[8 marks, 10 minutes]*

(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 22 = 0 + \frac{1}{2}a(5)^2$

$\Rightarrow a = 1.76\,ms^{-2}$ |M1A1

(b) $v = u + at = 0 + 1.76 \times 5 = 8.8ms^{-1}$ |M1A1

(c) $s = ut + \frac{1}{2}at^2 = 8.8 \times 3 - \frac{1}{2}9.8 \times 3^2$ |M1

$= -17.7\,m$ |M1A1

$\Rightarrow$ total height $= 22 + -17.7 = 4.3\,m$ |A1

A68 - ID: 3301 *[7 marks, 8 minutes]*

(a) $v^2 = u^2 + 2as \Rightarrow 338.56 = u^2 + 2 \times 9.8 \times 11.6$ |M1A1

$\Rightarrow u^2 = 111.2$

$\Rightarrow u = 10.545\,ms^{-1}$ |A1

(b) $v = u + at \Rightarrow 18.4 = -10.545 + 9.8T$ |M1A1

$\Rightarrow T = 2.954\,s$ |M1A1

A69 - ID: 7388 *[8 marks, 10 minutes]*

(a) $v = u + at \Rightarrow 0 = u - 2.8g$

$\Rightarrow u = 27.44\,ms^{-1}$ |M1A1

(b) $s = ut + \frac{1}{2}at^2 = 27.44 \times 5 - \frac{1}{2}g(5)^2$ |M1A1

$= 14.7\,m$ |A1

(c) $v^2 = u^2 + 2as \Rightarrow v^2 = 27.44^2 - 2g(-73) = 2183.75$ |M1A1

$\Rightarrow v = \sqrt{2183.75} = 46.73\,ms^{-1}$ |A1

A70 - ID: 5040 *[3 marks, 4 minutes]*

$v = u + at \Rightarrow 0 = u - 12g$ |M1A1

$\Rightarrow u = 117.6\,ms^{-1}$ |A1

A71 - ID: 7346 *[4 marks, 5 minutes]*

(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 3.1 = 0 + \frac{1}{2}gt^2$

$\Rightarrow t^2 = \frac{6.2}{g}$

$\Rightarrow t = \sqrt{\frac{6.2}{g}} = 0.795\,s$ |M1A1

(b) $v = u + at \Rightarrow v = 0 + 0.795g = 7.795\,ms^{-1}$ |M1A1

A72 - ID: 7357 *[7 marks, 8 minutes]*

For A $\Rightarrow V = 39.2 - gT$

For B $\Rightarrow V = 0 + gT$ M1A1

$\Rightarrow 39.2 - gT = gT$

$\Rightarrow 2gT = 39.2$

$\Rightarrow T = \frac{39.2}{2g} = 2\,s$ M1A1

$\Rightarrow V = gT = 19.6\,ms^{-1}$ B1

For A $\Rightarrow s = ut + \frac{1}{2}at^2 = 39.2(2) - \frac{1}{2}g(2)^2 = 58.8$

For B $\Rightarrow s = ut + \frac{1}{2}at^2 = \frac{1}{2}g(2)^2 = 19.6$

$\Rightarrow H = 58.8 + 19.6 = 78.4\,m$ M1A1

A73 - ID: 1887 *[6 marks, 7 minutes]*

(a) $(\updownarrow) \Rightarrow P \sin 35 = 40\,N$ M1A1

$\Rightarrow P = 69.7$ A1

(b) $(\leftrightarrow) \Rightarrow Q = P \cos 35$ M1A1

$\Rightarrow Q = 57.1\,N$ A1

A74 - ID: 3052 *[6 marks, 7 minutes]*

(a) $(\leftrightarrow)$ $T \sin 60 = 70$ M1A1

$\Rightarrow T = \frac{70}{\sin 60}$

$\Rightarrow T = 80.8N$ A1

(b) $(\updownarrow) W = T \cos 60$ M1A1

$\Rightarrow W = 80.8 \cos 60$

$\Rightarrow W = 40.4N$ M1A1

A75 - ID: 1910 *[6 marks, 7 minutes]*

(a) $(\updownarrow)$ $T \cos 50 = 6$ M1A1

$\Rightarrow T = \frac{6}{\cos 50}$

$\Rightarrow T = 9.33N$ A1

(b) $(\leftrightarrow)$ $T \sin 50 = F$ M1

$\Rightarrow F = 9.33 \sin 50$

$\Rightarrow F = 7.15N$ M1A1

A76 - ID: 1913 [6 marks, 7 minutes]

(a) ($\leftrightarrow$) $70\cos 40 = T\cos 65$ |$M1$

$T = 70\cos 40 \div \cos 65$

$= 126.9\,N$ |$M1A1$

(b) ($\updownarrow$) $W = 70\sin 40 + 126.9\sin 65$ |$M1$

$= 160\,N$ |$M1A1$

A77 - ID: 608 [7 marks, 8 minutes]

(a) ($\leftrightarrow$) $\Rightarrow T\cos 37 = 3$ |$M1A1$

$\Rightarrow T = 3.76N$ |$A1$

(b) ($\updownarrow$) $\Rightarrow T + T\sin 37 = W$ |$M1A1$

$\Rightarrow W = 3.76(1 + \sin 37) = 6.02\,N$ |$M1A1$

A78 - ID: 812 [6 marks, 7 minutes]

(a) ($\updownarrow$) $\Rightarrow P\sin 21 = 19$ |$M1A1$

$\Rightarrow P = 53.02N$ |$A1$

(b) ($\leftrightarrow$) $\Rightarrow Q = P\cos 21$ |$M1A1$

$\Rightarrow Q = 49.5N$ |$A1$

A79 - ID: 2957 [10 marks, 12 minutes]

(a) $T_1\sin 44 = T_2\sin 44 \Rightarrow T_1 = T_2$ |$M1A1$

(b) resolve $\updownarrow \Rightarrow T\cos 44 + T\cos 44 = 2g$ |$M1A1$

$\Rightarrow T = \dfrac{2g}{2\cos 44}$ |$A1$

$\Rightarrow T = 13.62\,N$ |$M1A1$

(c) resolve $\updownarrow \Rightarrow 90\cos 44 = mg$ |$M1A1$

$\Rightarrow m = \dfrac{90\cos 44}{g} = 6.61\,kg$ |$A1$

A80 - ID: 7276 [7 marks, 8 minutes]

(a) resolve $\leftrightarrow \Rightarrow T\sin 20 = 11$ |$M1A1$

$\Rightarrow T = 32.2\,N$ |$A1$

(b) resolve $\updownarrow \Rightarrow T\cos 20 = W$ |$M1A1$

$\Rightarrow W = 30.2\,N$ |$M1A1$

A81 - ID: 2886 [11 marks, 13 minutes]

(a) $(\nearrow) \Rightarrow 6g \sin 20 = 55 \cos\theta$ |M1A1

$\Rightarrow \cos\theta = \dfrac{6g \sin 20}{55} = 0.37$ |A1

(b) $(\nwarrow) \Rightarrow R = 6g \cos 20 + 55 \sin\theta$ |M1A1

$\Rightarrow R = 106.45N$ |M1A1

(c) $F = ma \Rightarrow 55 \cos 20 - 6g \sin 20 = 6a$ |M1A1

$\Rightarrow 31.57 = 6a$

$\Rightarrow a = 5.26\,ms^{-2}$ |M1A1

A82 - ID: 7303 [5 marks, 6 minutes]

(a) $(\updownarrow) \Rightarrow T_{AP} \sin\theta = 3g$ |M1A1

$\Rightarrow T_{AP} = \dfrac{3g}{\sin 34} = 52.58\,N$ |A1

(b) $(\leftrightarrow) \Rightarrow T_{BP} = T_{AP} \cos\theta = 52.58 \cos 34 = 43.59\,N$ |M1A1

A83 - ID: 7350 [17 marks, 20 minutes]

(a) information$\Rightarrow$ ring is smooth; box in equilibrium; string is light |B2

(b) Resolve $\leftrightarrow \Rightarrow 64 \cos\alpha = 64 \cos\beta$

$\Rightarrow \alpha = \beta$ |M1A1

(c) Resolve $\updownarrow \Rightarrow 64 \sin\alpha + 64 \sin\beta = 11g$ |M1B2A1

$\Rightarrow 128 \sin\alpha = 11g$

$\Rightarrow \sin\alpha = \frac{11g}{128} \Rightarrow \alpha = \sin^{-1} \frac{11g}{128} = 57.4°$ |A1

(d) Resolve $\updownarrow \Rightarrow T_P \sin 45 + T_Q \sin 22 = 11g$ |M2A1

Resolve $\leftrightarrow \Rightarrow T_P \cos 45 = T_Q \cos 22 + 11$ |M1A1

$\Rightarrow T_Q \cos 22 + 11 + T_Q \sin 22 = 11g$ |M1

$\Rightarrow T_Q (\cos 22 + \sin 22) = 11g - 11$

$\Rightarrow T_Q = \dfrac{11g - 11}{\cos 22 + \sin 22} = 74.4\,N$ |A1

$\Rightarrow T_P = \dfrac{T_Q \cos 22 + 11}{\cos 45} = 113.1\,N$ |A1

A84 - ID: 7404 [6 marks, 7 minutes]

(a) Resolve $\leftrightarrow \Rightarrow F \sin\beta = 0.3 \sin\alpha$ |M1A1

$\Rightarrow F = \dfrac{0.3 \sin 42}{\sin 62} = 0.2274\,N$ |A1

(b) Resolve $\updownarrow \Rightarrow F \cos\alpha + 0.3 \cos\beta = mg$ |M1A1

$\Rightarrow 0.169 + 0.1408 = mg$

$\Rightarrow m = 0.032\,kg$ |A1

A85 - ID: 5484 *[14 marks, 17 minutes]*

(a) $\tan\theta = \frac{4}{1}$

$\Rightarrow \theta = 76$ |$M1A1$

$\Rightarrow$ angle $= 166$ |$A1$

(b) $(5i - 7j) + (pi + qj) = (5 + p)i - (7 - q)j$ |$B1$

$\Rightarrow 7 - q = 4(5 + p)$ |$M1A1$

$\Rightarrow 4p + q + 13 = 0$ |$A1$

(c) $q = 3 \Rightarrow p = -4$ |$A1$

$\Rightarrow R = 1i - 4j$ |$M1$

$\Rightarrow |R| = \sqrt{17}$ |$M1A1$

$\Rightarrow \sqrt{17} = m11\sqrt{5}$ |$M1A1$

$\Rightarrow m = \frac{\sqrt{17}}{11\sqrt{5}} = 0.17$ |$A1$

A86 - ID: 7354 *[6 marks, 7 minutes]*

(a) $force = ma \Rightarrow \begin{pmatrix} -8 \\ 12 \end{pmatrix} + \begin{pmatrix} a \\ b \end{pmatrix} = 7\begin{pmatrix} 4 \\ 4 \end{pmatrix}$ |$M1B2$

$\Rightarrow \begin{pmatrix} -8 + a \\ 12 + b \end{pmatrix} = \begin{pmatrix} 28 \\ 28 \end{pmatrix}$

$\Rightarrow F = \begin{pmatrix} 36 \\ 16 \end{pmatrix}$ |$A1$

(b) $\theta = \tan^{-1}\frac{36}{16} = 66°$ |$M1A1$

A87 - ID: 7271 *[8 marks, 10 minutes]*

(a) $(\leftrightarrow)$ $49\cos 30 = T\cos 56$ |$M1A1$

$T = 49\cos 30 \div \cos 56$

$= 75.9\,N$ |$M1A1$

(b) $(\updownarrow)$ $mg = 49\sin 30 + 75.9\sin 56$ |$M1A1$

$= 87.4\,N$

$\Rightarrow m = 8.9\,kg$ |$M1A1$

A88 - ID: 1888 *[9 marks, 11 minutes]*

(a) $(\nwarrow) R = 4g\cos 15 + 45\sin 15$ |$M1A2$

$= 49.51N$ |$A1$

(b) $(\nearrow) F = 45\cos 15 - 4g\sin 15$ |$M1$

$= 33.32N$ |$A1$

$F = \mu R \Rightarrow \mu = \frac{F}{R} = \frac{33.32}{49.51}$ |$M2$

$\Rightarrow \mu = 0.67$ |$A1$

A89 - ID: 1890 *[8 marks, 10 minutes]*

	R = Reaction force; F = Resistant force	
$(\updownarrow)$	$R = 0.8 \times 9.8 + 2\sin\alpha$	$M1A1$
	$= 8.472\,N$	$A1$
$(\leftrightarrow)$	$F = 2\cos\alpha$	$M1$
	$= 1.897\,N$	$A1$
$F = \mu R$	$\Rightarrow \mu = \frac{F}{R}$	$M1$
	$\Rightarrow \mu = 0.224$	$M1A1$

A90 - ID: 1909 *[12 marks, 14 minutes]*

(a	$(\updownarrow)$	$R\cos 40 = 6g + F\cos 50$	$M1A1$
		$0.766R = 6g + 0.7R \times 0.643$	$B1$
		$\Rightarrow R = 186.1\,N$	$A1$
(b)	$(\leftrightarrow)$	$H = F\cos 40 + R\cos 50$	$M1A1$
		$H = 0.7 \times 186.1 \times 0.766 + 186.1 \times 0.643$	
		$H = 219.4\,N$	$A1$
(c)	$(\swarrow)$	$weight = 6g\cos 50 = 37.8\,N$	$B1$
		$R1 = 6g\cos 40 = 45\,N$	$M1A1$
		$F1\max = 0.7R1 = 31.5$	$M1$
		$37.8 > 31.5 \Rightarrow$ box moves	$A1$

A91 - ID: 1911 *[10 marks, 12 minutes]*

$\swarrow$	$F + 1.6g\sin 33 = T\cos 17 \quad (1)$	$M1A1$
$\nwarrow$	$R + T\sin 17 = 1.6g\cos 33 \quad (2)$	$M1A1$
	$F = \frac{1}{3}R \quad (3)$	$B1$
	$(1),(3) \Rightarrow \frac{1}{3}R + 1.6g\sin 33 = T\cos 17$	
	$\Rightarrow R = 3T\cos 17 - 4.8g\sin 33 \quad (4)$	$M1A1$
	$(2),(4) \Rightarrow 3T\cos 17 - 4.8g\sin 33 + T\sin 17 = 1.6g\cos 33$	
	$\Rightarrow (3\cos 17 + \sin 17)T = 1.6g\cos 33 + 4.8g\sin 33$	
	$\Rightarrow T = \frac{1.6g\cos 33 + 4.8g\sin 33}{3\cos 17 + \sin 17}$	$M1A1$
	$\Rightarrow T = 12.26$ newtons	$A1$

A92 - ID: 1912 [8 marks, 10 minutes]

(↖) $R = 7g\cos\alpha + 20\sin\alpha$ |$M2$
$= 5.6g + 12$ |$A1$
(↗) $F + 20\cos\alpha = 7g\sin\alpha$ |$M2$
$F + 16 = 4.2g$ |$A1$
$\mu = \frac{F}{R} = \frac{4.2g-16}{5.6g+12}$
$= 0.376$ |$M1A1$

A93 - ID: 7284 [14 marks, 17 minutes]

(a) Resolve perpendicular to the plane $\Rightarrow 21 = F\sin 25 + 13\cos 25$ |$M1A1$
$\Rightarrow F = 21.81\,N$ |$M1A1$
(b) Resolve parallel to the plane $\Rightarrow F\cos 25 = 13\sin 25 + 21\mu$ |$M2A1$
$\Rightarrow 21\mu = 21.81\cos 25 - 13\sin 25$
$\Rightarrow \mu = 0.68$ |$M1A1$
(c) normal reaction $= 13\cos 25$ |$M1A1$
component down slope $= 13\sin 25 = 5.5\,N$
maximum friction $= \mu \times 13\cos 25 = 8\,N$ |$B1M1$
$8 > 5.5 \Rightarrow$ parcel does not move |$A1$

A94 - ID: 2915 [4 marks, 5 minutes]

Resolve ↗ up the plane $\Rightarrow F + 33\cos 38 = 103 sin38$ |$M1A1$
$\Rightarrow F = 103 sin38 - 33\cos 38 = 37.41\,N$ |$M1A1$

A95 - ID: 7273 [9 marks, 11 minutes]

(↔) $F = \mu R \Rightarrow P\cos 18 = \mu R$ |$B1M1A1$
↕ $\Rightarrow R + P\sin 18 = 22g$ |$M1A1$
$\Rightarrow P\cos 18 = 0.2(22g - P\sin 18)$ |$M1$
$\Rightarrow P(\cos 18 + 0.2\sin 18) = 4.4g$ |$M1$
$\Rightarrow P = \dfrac{4.4g}{\cos 18 + 0.2\sin 18} = 42.6\,N$ |$M1A1$

A96 - ID: 7280 [10 marks, 12 minutes]

R = normal reaction; F = frictional force
(a) (↕) $\Rightarrow R + 1.4\sin 42 = 0.25 \times 9.8$ |$M1A1$
$\Rightarrow R = 1.51\,N$ |$M1A1$
(b) (↔) $F = 1.4\cos 42 = 1.04\,N$ |$M1A1$
$\mu = \dfrac{F}{R} = \dfrac{1.04}{1.51}$ |$B1M1A1$
$= 0.688$ |$A1$

A97 - ID: 3305 [11 marks, 13 minutes]

(a) $(\nwarrow) R = 6g\cos 29 + 47\sin 48$ | $M1A2$
$= 86.355\,N$ | $M1A1$
(b) $(\searrow) \Rightarrow F + 6g\sin 29 = 47\cos 48$ | $M1A1$
$\Rightarrow F = 2.942\,N$ | $M1A1$
$F = \mu R \quad \Rightarrow \mu = 2.942 \div 86.355 = 0.03$ | $M1A1$

A98 - ID: 7334 [8 marks, 10 minutes]

(a) $(\leftrightarrow)$ frictional force $= 13\sin 53 - 13\sin 27$
$= 4.48\,N$ | $M1A1$
$\Rightarrow$ direction: to the left | $A1$
(b) $(\updownarrow) \Rightarrow N + 13\cos 53 + 13\cos 27 = 27$ | $M1A1$
$\Rightarrow N = 7.593\,N$ | $A1$
$F = \mu R \quad \Rightarrow \mu = \frac{4.48}{7.593} = 0.59$ | $M1A1$

A99 - ID: 7397 [7 marks, 8 minutes]

(a) $(\nwarrow) R = 3.98g\cos 31 = 33.433\,N$ | $M1A1$
(b) $(\swarrow) \Rightarrow F = 3.98g\sin 31 = 20.089\,N$ | $M1A1$
$F = \mu R \quad \Rightarrow \mu = 20.089 \div 33.433 = 0.60$ | $M1A2$

A100 - ID: 5714 [11 marks, 13 minutes]

(a) $(\updownarrow)$ $R\cos\alpha + F\sin\alpha = 1.3g$ | $M1A2$
$F = 0.7R \Rightarrow R = \dfrac{1.3g}{\cos\alpha + 0.7\sin\alpha}$ | $B1M1$
$\Rightarrow R = 10.44\,N$ | $A1$
(b) $(\leftrightarrow)$ $H + 0.7R\cos\alpha = R\sin\alpha$ | $M1A2$
$\Rightarrow H = R\sin\alpha - 0.7R\cos\alpha$
$\Rightarrow H = 0.42$ | $M1A1$

A101 - ID: 6975 [9 marks, 11 minutes]

$(\leftrightarrow)$ $F = P\cos 57$ | $M1A1$
$F = 0.3R$ | $B1$
$(\updownarrow) P\sin 57 + R = 10g$ | $M1A2$
$\Rightarrow P\cos 57 = 0.3(10g - P\sin 57)$ | $M1$
$\Rightarrow P(\cos 57 + 0.3\sin 57) = 3g$ | $M1$
$\Rightarrow P = \dfrac{3g}{\cos 57 + 0.3\sin 57} = 37$ | $A1$

A102 - ID: 7342 *[8 marks, 10 minutes]*

(a) ($\leftrightarrow$) $force = ma \Rightarrow 20\cos 30 = 3a$ |$M1A1$

$\Rightarrow a = 5.77\,ms^{-2}$ |$A1$

(b) normal reaction $= 3g + 20\sin 30 = 39.4\,N$ |$M1A1$

friction force $= 20\cos 30 = 17.32\,N$ |$B1$

$\mu = \frac{F}{N} = \frac{17.32}{39.4} = 0.44$ |$M1A1$

A103 - ID: 1906 *[13 marks, 16 minutes]*

(a) Forces at B $\Rightarrow 9mg - T = 9m.\frac{1}{2}g$

$\Rightarrow T = 9mg - 9m.\frac{1}{2}g$ |$M1A1$

$\Rightarrow T = 4.5mg$ |$M1A1$

(b) Forces at A $\Rightarrow T - F - 3mg.\frac{3}{5} = 3m.\frac{1}{2}g$ |$M1A2$

$\Rightarrow F = T - 3mg.\frac{3}{5} - 3m.\frac{1}{2}g$

$\Rightarrow F = (\frac{9}{2} - \frac{9}{5} - \frac{3}{2})mg$

$\Rightarrow F = \frac{12}{10}mg$ |$M1A1$

$N = 3mg.\frac{4}{5}$ |$M1A1$

$\Rightarrow \mu = \frac{F}{N} = \frac{12}{10} \times \frac{5}{12} = 0.$ |$M1A1$

A104 - ID: 1907 *[10 marks, 12 minutes]*

(a) $v^2 = u^2 + 2as \Rightarrow 7^2 = 10^2 + 2a \times 5$ |$M1$

$\Rightarrow a = -5.1ms^{-2}$ |$A1$

(b) $F = 11g\sin 22 + 11 \times 5.1$ |$M1$

$N = 11g\cos 22$ |$M1$

$\mu = \frac{F}{N} = \frac{11g\sin 22 + 11 \times 5.1}{11g\cos 22}$ |$M1A1$

$= \frac{9.8\sin 22 + 5.1}{9.8\cos 22}$

$= 0.965$ |$M1A1$

(c) $v^2 = u^2 + 2as \Rightarrow 0 = 7^2 + 2 \times -5.1s$

$\Rightarrow 10.2s = 49$

$\Rightarrow s = 4.8$ |$A1$

$\Rightarrow$ max AC $= 5 + 4.8 = 9.8\,m$ |$A1$

A105 - ID: 1908 *[10 marks, 12 minutes]*

(a) (↖) $R = 2g\cos 35$ |$M1A1$

$F = \mu R \Rightarrow F = 0.5 \times 2g\cos 35$ |$M1$

$\Rightarrow F = 8\,Ns$ |$A1$

(b) (↗) $2a = -F - 2g\sin 35$ |$M1A1$

$\Rightarrow 2a = -8 - 11.2$

$\Rightarrow a = -9.635$ |$A1$

$v^2 = u^2 + 2as \Rightarrow 0 = 6^2 - 19.27s$ |$M1A1$

$\Rightarrow s = \frac{36}{19.27}$

$\Rightarrow s = 1.87\,m.$ |$M1A1$

A106 - ID: 7288 *[11 marks, 13 minutes]*

(a) Resolve perpendicular to the plane $\Rightarrow R = 0.4g\cos\theta = 0.32g$ |$M1A1$

Resolve parallel to the plane $\Rightarrow 4 = F + 0.4g\sin\theta$ |$M1A1$

$F = \mu R \Rightarrow 4 = 0.32g\mu + 0.24g$ |$M1$

$\Rightarrow \mu = 0.53$ |$M1A1$

(b) $F = ma \Rightarrow 4a = 4g\sin\theta - 0.53 \times 4g\cos\theta$ |$M1A2$

$\Rightarrow 4a = 2.4g - 1.68g$

$\Rightarrow a = 1.76ms^{-2}$ |$A1$

A107 - ID: 374 *[14 marks, 17 minutes]*

(a) $f = \mu R \Rightarrow P\cos 25 = \mu R$ |$B1M1A1$

$\Rightarrow R + P\sin 25 = 26g$ |$M1A1$

$\Rightarrow P\cos 25 = \mu(26g - P\sin 25)$

$\Rightarrow (\cos 25 + \mu\sin 25)P = 26\mu g$

$\Rightarrow P = \frac{26\mu g}{\cos 25 + \mu\sin 25}$ |$M1A1$

$\Rightarrow P = \frac{50.96}{0.991} = 51\,N$ |$A1$

(b) $\updownarrow \Rightarrow R + 170\sin 25 = 26g$

$\Rightarrow R = 183$ |$M1A1$

$\leftrightarrow \Rightarrow 170\cos 25 - \mu R = 26a$ |$M1A1$

$\Rightarrow a = \frac{170\cos 25 - 0.2 \times 183}{26} = 4.5\,ms^{-2}$ |$M1A1$

A108 - ID: 7305 [11 marks, 13 minutes]

(a) frictional force $= \mu N = 0.1 \times 10g$ |$M1A1$

$= 9.8\,N$ |$A1$

(b) For the block $\Rightarrow$ $force = ma \Rightarrow 10a = T - 9.8$ |$M1A1$

For the particle $\Rightarrow$ $force = ma \Rightarrow 7a = 7g - T$ |$M1$

$\Rightarrow 7a = 7g - (10a + 9.8)$ |$A1$

$\Rightarrow 17a = 58.8$

$\Rightarrow a = 3.459\,ms^{-2}$ |$A1$

(c) $v^2 = u^2 + 2as \Rightarrow 1.9^2 = 0 + 2 \times 3.459s$ |$M1A1$

$\Rightarrow s = 0.522\,m$ |$A1$

A109 - ID: 7329 [16 marks, 19 minutes]

(a) $F = \mu F \Rightarrow \mu = \frac{4.6}{15.2} = \frac{23}{76}$ |$M1A1$

(b) vertical component $= 15.2 - 4.6\sin 32 = 12.76\,N$ |$M1A2$

frictional force $= \frac{23}{76} \times 12.76 = 3.86\,N$ |$M1A1$

(c) $force = ma \Rightarrow 4.6\cos 32 - 3.86 = \frac{15.2}{g}a$ |$B1M1A1$

$\Rightarrow a = 0.02\,ms^{-2}$ |$A2$

(d) vertical component $= 15.2 - 4.6\cos 32 = 11.3\,N$

frictional force $= \frac{23}{76} \times 11.3 = 3.42\,N$ |$B1$

horizontal component of force $= 4.6\sin 32 = 2.44\,N$ |$B1$

$2.44 < 3.42 \Rightarrow$ frictional force $= 2.44\,N$ |$M1A1$

A110 - ID: 7392 [11 marks, 13 minutes]

(a) Normal reaction, $N = 5g\cos\alpha$ |$M1A1$

Frictional force $= \mu N = \frac{1}{6} \times 5g\frac{12}{13} = \frac{10}{13}g$ |$B1$

$force = ma \Rightarrow 5g\sin\alpha - \frac{10}{13}g = 5a$ |$M1A2$

$\Rightarrow a = \left(\frac{5}{13} - \frac{1}{78}\right)g = 2.26\,ms^{-2}$ |$A1$

(b) $force = ma \Rightarrow T - 5g\sin\alpha - \frac{10}{13}g = 0$ |$B1M1A1$

$\Rightarrow T = 26.38\,N$ |$A1$

A111 - ID: 6974 [9 marks, 11 minutes]

$F = ma \Rightarrow 0.5g\sin\theta - F = 0.5a$ |$M1A2$

$F = \frac{1}{6}R$ |$B1$

$R = 0.5g\cos\theta$ |$M1A1$

$\Rightarrow 0.5g\sin\theta - 0.5a = \frac{1}{6}0.5g\cos\theta$ |$M1$

$\Rightarrow a = g\sin\theta - \frac{1}{6}g\cos\theta = \frac{7}{10}g\,ms^{-2}$ |$B1A1$

A112 - ID: 7321 *[8 marks, 10 minutes]*

(a) Normal reaction, $N = 6g + 39\sin 38$ |$M1A1$

$= 82.8\,N$ |$A1$

(b) Friction force, $F = 39\cos 38 = 30.7\,N$ |$M1A1$

(c) $F \leq \mu N \Rightarrow \mu \geq \frac{F}{N}$

$\Rightarrow \mu \geq \dfrac{30.7}{82.8}$ |$M1A1$

$\Rightarrow \mu \geq 0.371$ |$A1$

A113 - ID: 7347 *[8 marks, 10 minutes]*

Normal reaction, $N = 2.6g\sin 56 = 21.1\,N$ |$B1$

Friction force, $F = \mu \times N = 4.2\,N$ |$M1A1$

$force = ma \Rightarrow 2.6gcos56 - F = 2.6a$

$\Rightarrow 14.2 - 4.2 = 2.6a$ |$B1M1$

$\Rightarrow a = 5.5 - 1.6 = 3.9\,ms^{-2}$ |$A1$

distance $AC = \frac{2.4}{\cos 56} = 4.3\,m$ |$B1$

$v^2 = u^2 + 2as = 0 + 2 \times 3.9 \times 4.3 = 33.1$ |$M1A1$

$\Rightarrow v = \sqrt{33.1} = 5.8\,ms^{-1}$ |$A1$

A114 - ID: 7762 *[12 marks, 14 minutes]*

(a) $\updownarrow \Rightarrow R + 57\sin 34 = 15g$ |$M1A1$

$\Rightarrow R = 15g - 57\sin 34 = 115.13\,N$ |$A1$

(b) $\leftrightarrow \Rightarrow F = 57\cos 34 = 47.26\,N$ |$M1A1$

$\mu = \frac{F}{R} = \frac{47.26}{115.13} = 0.41$ |$M1A1$

(c) $force = ma \Rightarrow T\cos 34 - 0.41R = 15 \times 0.8$ |$B1M1$

$\Rightarrow T\cos 34 - 0.41(15g - T\sin 34) = 15 \times 0.8$ |$A1$

$\Rightarrow T(\cos 34 + 0.41\sin 34) = 6.15g + 12$

$\Rightarrow T = \frac{6.15g + 12}{\cos 34 + 0.41\sin 34} = 68.29$ |$M1A1$

A115 - ID: 7299 [15 marks, 18 minutes]

(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 2.2 = 0 + \frac{1}{2}a(3)^2$ |M1A1

$\Rightarrow a = 0.489ms^{-2}$ |A1

(b) Normal reaction, $N = 0.6g\cos 29$ |A1

$force = ma \Rightarrow 0.6a = 0.6g\sin 29 - F$

$\Rightarrow 0.293 = 0.6g\sin 29 - \mu(0.6g\cos 29$ |M1A1

$\Rightarrow \mu = \dfrac{0.6g\sin 29 - 0.293}{0.6g\cos 29} = 0.5$ |M1A1

(c) Resolve $\updownarrow \Rightarrow N\cos 29 = 0.6g + F\sin 29$

$\Rightarrow N\cos 29 = 0.6g + \mu N\sin 29$

$\Rightarrow N(\cos 29 - \mu\sin 29) = 0.6g$

$\Rightarrow N = \dfrac{0.6g}{\cos 29 - \mu\sin 2} = 9.28$ |M1A1

$\Rightarrow F = \mu N = 4.62$ |A1

Resolve $\leftrightarrow \Rightarrow X = F\cos 29 + N\sin 29$ |M1A2

$= 8.54$ |A1

A116 - ID: 411 [11 marks, 13 minutes]

(a) Cons of lin. mom $\Rightarrow 6000 \times 4 - 2 \times 3000 = 9000 \times V$ |M1A1

$\Rightarrow V = \frac{18000}{9000} = 2$ |A1

$\Rightarrow$ direction $= \vec{AB}$ |A1

(b) impulse by B on A $= 6000(4 - 2)$ |M1A1

$= 12000Ns$ |A1

(c) $F = Ma \Rightarrow 240 = 9000a$ |M1

$\Rightarrow a = \frac{240}{9000} = 0.027$ |A1

$v^2 = u^2 + 2as \Rightarrow 0 = 2^2 - 2 \times 0.027 \times d$ |M1

$\Rightarrow d = \frac{2^2}{2 \times 0.027} = 75$ |A1

A117 - ID: 1949 [6 marks, 7 minutes]

(a) Momentum : before = after

$\Rightarrow 0.7 \times 3 - 0.2 \times 2 = 0.7 \times 1.7 + 0.2 \times V$ |M1A1

$\Rightarrow v = 2.55m/s$ |A1

(b) Impulse $= 0.2(2 + 2.55)$ |M1A1

$= 0.91\,Ns$ |A1

A118 - ID: 428 [3 marks, 4 minutes]

Impulse $= mv - mu$ |M1

$= (0.4 \times -9) - (0.4 \times 10)$ |A1

$= -7.6\,Ns$ |A1

A119 - ID: 1950 [6 marks, 7 minutes]

(a) Cons of lin. mom $\Rightarrow 1900 \times 3 = (1900 + 1000)V$ | $M1A1$

$\Rightarrow V = \frac{5700}{2900} = 1.97ms^{-1}$ | $A1$

(b) $R \times 8 = 2900V$ | $M1$

$= 5713$ | $A1$

$\Rightarrow R = 714.13$ | $A1$

A120 - ID: 1951 [7 marks, 8 minutes]

(a) Momentum of A $\Rightarrow 1 = 0.5(4 + V)$ | $M1A1$

$\Rightarrow V = -2\, m/s$ | $A1$

(b) Momentum of B $\Rightarrow 1 = m(1.5 + 0.7)$ | $M1$

$\Rightarrow m = 0.45$ | $A1$

or $\Rightarrow 1 = m(1.5 - 0.7)$ | $M1$

$\Rightarrow m = 1.25$ | $A1$

A121 - ID: 1952 [11 marks, 13 minutes]

(a) Cons of mom. $\Rightarrow 1800 \times 9 + 3000 \times 6 = 1800 \times 4 + 3000 \times S$ | $M1$

$\Rightarrow S = \frac{27000}{3000} = 9ms^{-1}$ | $M1A1$

(b) $v^2 = u^2 + 2as \Rightarrow 0 = 4^2 + 2 \times -\frac{400}{1800} \times AB$ | $M1$

$\Rightarrow AB = \frac{16}{0.4444444444444444} = 36\, m$ | $M1A1$

(c) $v = u + at \Rightarrow 0 = 4 - \frac{400}{1800} t$ | $M1$

$\Rightarrow t = \frac{7200}{400} = 18$ | $M1A1$

$\Rightarrow$ PQ $= 8.7 \times 18 - 36 = 120.6km$ | $M1A1$

A122 - ID: 1954 [5 marks, 6 minutes]

(a) Cons of lin. mom $\Rightarrow 2300 \times 9 = 2300V + 2500 \times 7$ | $M1A1$

$\Rightarrow V = \frac{3200}{2300} = 1.39ms^{-1}$ | $B1$

(b) impulse of P on Q $= 2300(9 - 1.39)$ | $M1$

$= 17503\, Ns$ | $A1$

A123 - ID: 1956 *[7 marks, 8 minutes]*

(a) magnitude$= 0.12 \times 5$ | $M1$
$= 0.6\,Ns$ | $A1$
(b) $0.6 = 0.12 \times 1.3 + 0.14 \times x = 0.156 + 0.14x$ | $M1$
$x = \frac{0.444}{0.14} = 3.171\,m/s$ | $M1A1$
(c) magnitude$= 0.6 - 0.156 = 0.444\,Ns$ | $M1A1$

A124 - ID: 804 *[8 marks, 10 minutes]*

(a) let : speed of $A = v$, speed of $B = 2v$
$CLM \Rightarrow 0.2 \times 7 - 0.5 \times 4 = 0.2 \times v + 0.5 \times 2v$ | $M2A1$
$\Rightarrow -0.6 = 1.2v$
$\Rightarrow v = -0.5\,ms^{-1}$ | $M1A1$
(b) magnitude $= 0.5 \times (4 + -1) = 1.5\,Ns$ | $M1A2$

A125 - ID: 618 *[8 marks, 10 minutes]*

(a) $CLM \Rightarrow 2 \times 2 + 5 \times 3.5 = 7 \times v$ | $M1A1$
$\Rightarrow v = 3.07\,ms^{-1}$ | $A1$
(b) $CLM \Rightarrow 3 \times 2 - m \times 2 = -3 \times 6 + m \times 4$ | $M1A1$
$\Rightarrow v = 4\,ms^{-1}$ | $A1$
(c) $I = 4(2 + 4) = 24\,Ns$ | $M1A1$

A126 - ID: 763 *[7 marks, 8 minutes]*

(a) $CLM \Rightarrow 0.5 \times 7 - 0.3 \times 4 = 0.5 \times v + 0.3 \times 2$ | $M1A1$
$\Rightarrow v = 3.4\,ms^{-1}$, direction unchanged | $A2$
(b) magnitude $= 0.3 \times (4 + 2) = 1.8\,Ns$ | $M1B1A1$

A127 - ID: 485 *[10 marks, 12 minutes]*

(a) $CLM \Rightarrow 0.7u = 0.7 \times -6 + 0.4 \times 6$ | $M1A1$
$\Rightarrow u = -2.57$ | $M1A1$
(b) magnitude $= 0.4 \times 6 = 2.4\,Ns$ | $M1A1$
(c) $v = u + at \Rightarrow 0 = 6 + 1.1a$
$\Rightarrow a = -5.45$ | $M1A1$
$\Rightarrow F = ma = 0.4 \times 5.45 = 2.18$ | $M1A1$

A128 - ID: 2956 [5 marks, 6 minutes]

(a) $CLM \Rightarrow 3\begin{pmatrix}3\\-8\end{pmatrix} + 7\begin{pmatrix}-5\\7\end{pmatrix} = 10v$ |$M1A1$

$\Rightarrow v = \frac{1}{10}\begin{pmatrix}-26\\25\end{pmatrix} = \begin{pmatrix}-2.6\\2.5\end{pmatrix}$ |$A1$

(b) speed $= \sqrt{-2.6^2 + 2.5^2}$ |$M1$

$= 3.61\,ms^{-1}$ |$A1$

A129 - ID: 7274 [7 marks, 8 minutes]

(a) impulse on A $= 0.2(8 - -2) = 2\,Ns$ |$M1A2$

(b) $PCM \Rightarrow 0.2 \times 8 + m \times -5 = 0.2 \times -2 + m \times 2$ |$M1A1$

$\Rightarrow 1.6 - 5m = -0.4 + 2m$

$\Rightarrow 2 = 7m$

$\Rightarrow m = \frac{2}{7}\,kg$ |$M1A1$

A130 - ID: 7422 [6 marks, 7 minutes]

(a) CLM $\Rightarrow 5 \times 7 + 3 \times -7 = 8 \times v$ |$M1A1$

$\Rightarrow 14 = 8v$

$\Rightarrow v = 1.75\,ms^{-1}$ |$A1$

(b) CLM $\Rightarrow 5 \times 7 + 3 \times -7 = 5 \times 0.3 + 3v$ |$M1A1$

$\Rightarrow 14 = 1.5 + 3v$

$\Rightarrow v = 4.17\,ms^{-1}$ |$A1$

A131 - ID: 2883 [6 marks, 7 minutes]

(a) Impulse $= 6(8 - 2) = 36\,Ns$ |$M1A1$

(b) CLM $\Rightarrow 6 \times 8 - m \times 3 = 6 \times 2 + m \times 3$ |$M1A1$

$\Rightarrow 36 = 6m$ |$M1$

$\Rightarrow m = 6\,kg$ |$A1$

A132 - ID: 3300 [6 marks, 7 minutes]

(a) Impulse $= m(v - u) \Rightarrow 4 = 0.8(v - 0)$ |$M1$

$\Rightarrow v = 5\,ms^{-1}$ |$M1A1$

(b) CLM $\Rightarrow 0.8 \times 5 + 0 = 0.8v + 0.8 \times 5$ |$M1$

$\Rightarrow 4 = 0.8v + 4$

$\Rightarrow v = 0\,ms^{-1}$ |$M1A1$

A133 - ID: 4576 [5 marks, 6 minutes]

$CLM \Rightarrow (63 \times 3) + (37 \times -2) = (63 + 37) \times v$ |$B2M1$
$\Rightarrow 115 = 100v$
$\Rightarrow v = 1.15\,ms^{-1}$ |$A1$
$\Rightarrow$ direction = same as 1st skater |$B1$

A134 - ID: 7304 [5 marks, 6 minutes]

(a) $CLM \Rightarrow 7\begin{pmatrix}3U\\U\end{pmatrix} + 14\begin{pmatrix}V\\-4\end{pmatrix} = 21\begin{pmatrix}V\\-1\end{pmatrix}$ |$M1A1$
$\Rightarrow 7U - 56 = -21$
$\Rightarrow U = 5$ |$A1$
(b) $CLM \Rightarrow 21U + 14V = 21V$
$\Rightarrow 21U = 7V$
$\Rightarrow 105 = 7V \Rightarrow V = 15$ |$M1A1$

A135 - ID: 7314 [8 marks, 10 minutes]

(a) $CLM \Rightarrow m \times 4 + 3 \times -4 = m \times -0.4 + 3 \times 0.4$ |$M1A1$
$\Rightarrow 4.4m = 13.2$
$\Rightarrow m = 3\,kg$ |$A1$
(b) moves to right $\Rightarrow m \times 4 + 3 \times -4 = (m + 3) \times 0.4$ |$M1A1$
$\Rightarrow 3.6m = 13.2$
$\Rightarrow m = 3.7\,kg$ |$A1$
(b) moves to left $\Rightarrow m \times 4 + 3 \times -4 = (m + 3) \times -0.4$ |$M1$
$\Rightarrow 4.4m = 10.8$
$\Rightarrow m = 2.5\,kg$ |$A1$

A136 - ID: 7335 [10 marks, 12 minutes]

(a) $CLM \Rightarrow 2400 \times 5 + 3600 \times -3 = 6000 \times v$ |$B2A1$
$\Rightarrow 1200 = 6000v$
$\Rightarrow v = 0.2\,ms^{-1}$ |$A1$
$\Rightarrow$ B has changed direction |$B1$
(b) $CLM \Rightarrow 2400 \times 5 + 3600 \times -3 = 2400 \times -v + 3600 \times v$ |$B1M1$
$\Rightarrow 1200 = 1200v$
$\Rightarrow v = 1\,ms^{-1}$ |$A1$
(c) change = $2400 \times 5 - 2400 \times -1$ |$M1$
$= 14400\,kgms^{-1}$ |$A1$

A137 - ID: 7401 *[11 marks, 13 minutes]*

(a) $CLM \Rightarrow 1.6 \times 5.6 + 0.052 \times 0 = 1.65 \times v$ | $M2B2$
$\Rightarrow 8.96 = 1.65v$
$\Rightarrow v = 5.4\,ms^{-1}$ | $A1$

(b) $force = ma \Rightarrow 1.65g - 1251 = 1.65a$ | $M1A1$
$\Rightarrow a = -747.5\,ms^{-2}$ | $A1$

(c) $v^2 = u^2 + 2as \Rightarrow 0 = 5.4^2 - 1494.9s$ | $M1A1$
$\Rightarrow s = 1.95\,cm$ | $A1$

A138 - ID: 7405 *[9 marks, 11 minutes]*

(a) $CLM \Rightarrow 4m \times 4u + 6m \times -3u = 4m \times -3u + 6m \times v$ | $M2B2$
$\Rightarrow 10u = 6v$
$\Rightarrow v = \frac{5}{3}u\,ms^{-1}$ | $A1$

(b) $impulse = mv - mu = 4m(u + 3u)$ | $M2A1$
$= 16mu\,Ns$ | $A1$

A139 - ID: 5679 *[9 marks, 11 minutes]*

(a) CLM $\Rightarrow km \times 4u - m \times 6u = -km \times 2u + m \times v$ | $M1$
$\Rightarrow v = 4ku - 6u + 2ku = 6ku - 6u$ | $M1A1$

(b) $k > 2 \Rightarrow v > 0$ | $M1A1$
$\Rightarrow$ direction reversed | $A1$

(c) for B $\Rightarrow$ impulse $= m(6ku - 6u - -6u) = 16mu$ | $M1A2$

A140 - ID: 6973 *[6 marks, 7 minutes]*

(a) For A $\Rightarrow -\dfrac{8mu}{3} = 4m(v_A - 4u)$ | $M1A1$
$\Rightarrow -\dfrac{8}{3}u = 4v_A - 16u$
$\Rightarrow v_A = \dfrac{40}{12}u$ | $A1$

(b) For B $\Rightarrow \dfrac{8mu}{3} = m(v_B - -2u)$ | $M1A1$
$\Rightarrow \dfrac{8}{3}u = v_B + 2u$
$\Rightarrow v_B = \dfrac{2}{3}u$ | $A1$

A141 - ID: 7316 *[3 marks, 4 minutes]*

CLM $\Rightarrow 2.2 \times 10 + 1.8 \times 6 = 4 \times v$ | $M1A1$
$\Rightarrow 32.8 = 4 \times v$
$\Rightarrow v = 8.2\,ms^{-1}$ | $A1$

A142 - ID: 7339 *[6 marks, 7 minutes]*

(a) CLM $\Rightarrow 0.6 \times 8 + m \times 0 = 0.6 \times 0.9 + m \times 7$ | $M1A1$

$\Rightarrow 4.26 = 7m$

$\Rightarrow m = 0.61\,kg$ | $A1$

(b) CLM $\Rightarrow 0.6 \times 8 + m \times 0 = 0.6 \times -0.9 + m \times 7$ | $M1A1$

$\Rightarrow 5.34 = 7m$

$\Rightarrow m = 0.76\,kg$ | $A1$

A143 - ID: 7348 *[12 marks, 14 minutes]*

(a) $v_p = u_p + at = 7 - 0.4 \times 1 = 6.6\,ms^{-1}$ | $M1A1$

$v_q = u_q + at = 0.8 - 0.4 \times 1 = 0.4\,ms^{-1}$ | $M1A1$

CLM $\Rightarrow 0.6 \times 6.6 + 0.4 \times -0.4 = 1v$

$\Rightarrow 3.96 - 0.16 = 1v$

$\Rightarrow v = 3.8\,ms^{-1}g$ | $M1A1$

(b) Q stops $\Rightarrow 0 = 0.8 - 0.4t$

$\Rightarrow t = 2$ | $M1A1$

$s_q = ut + \frac{1}{2}at^2 = 0.8 \times 2 - \frac{1}{2}0.4(2)^2 = 0.8\,m$ | $M1A1$

$s_p = 7 \times 3 - \frac{1}{2}0.4(3)^2 = 19.2\,m$ | $A1$

$\Rightarrow$ distance $= 0.8 + 19.2 = 20\,m$ | $A1$

A144 - ID: 7764 *[5 marks, 6 minutes]*

(a) CLM $\Rightarrow 1\begin{pmatrix} 7 \\ -5 \end{pmatrix} + 9\begin{pmatrix} -5 \\ 6 \end{pmatrix} = 10v$ | $M1A1$

$\Rightarrow v = \frac{1}{10}\begin{pmatrix} -38 \\ 49 \end{pmatrix} = \begin{pmatrix} -3.8 \\ 4.9 \end{pmatrix}$ | $A1$

(b) speed $= \sqrt{-3.8^2 + 4.9^2} = 6.2ms^{-1}$ | $M1A1$

A145 - ID: 7268 *[6 marks, 7 minutes]*

(a) impulse on A $= 3(14 - 3) = 33\,Ns$ | $M1A1$

(b) *PCM* $\Rightarrow 3 \times 14 + m \times -8 = 3 \times 3 + m \times 4$ | $M1A1$

$\Rightarrow 42 - 8m = 9 + 4m$

$\Rightarrow 33 = 12m$

$\Rightarrow m = \frac{11}{4}\,kg$ | $M1A1$

A146 - ID: 1889 *[7 marks, 8 minutes]*

(a) At A(↕) $F = ma \Rightarrow T - 2mg = 2ma$ |$M1$

$\Rightarrow T - 2mg = 2m(\frac{3}{4}g)$ |$A1$

$\Rightarrow T = 2mg + 2m(\frac{3}{4}g) = \frac{14}{4}mg$ |$A1$

(b) At B(↕) $F = ma \Rightarrow kmg - T = kma$ |$M1$

$\Rightarrow kmg - \frac{14}{4}mg = km\frac{3}{4}g$ |$A1$

$\Rightarrow k - \frac{14}{4} = k\frac{3}{4}$

$\Rightarrow 4k - 14 = 3k$ |$M1$

$\Rightarrow k = 14$ |$A1$

A147 - ID: 1953 *[14 marks, 17 minutes]*

(a) Forces at B $\Rightarrow 2g - T = 2 \times 0.3g$

$\Rightarrow T = 2g - 0.6g$ |$M1$

$\Rightarrow T = 13.72N$ |$M1A1$

(b) Forces at A $\Rightarrow T - mg.\sin 30 = m \times 0.3g$ |$M1$

$\Rightarrow 1.4g - 0.5mg = 0.3mg$ |$M1$

$\Rightarrow 1.4 = 0.8m$

$\Rightarrow m = 1.75$ |$M1A1$

(c) $v^2 = u^2 + 2as \Rightarrow v^2 = 0 + 2 \times 0.3g \times 0.25$ |$M1$

$\Rightarrow v = \sqrt{1.47}$

$\Rightarrow \text{impulse} = 2 \times \sqrt{1.47} = 2.425N$ |$M1A1$

(d) $v = u + at \Rightarrow 0 = \sqrt{1.47} - (g\sin 30)t$ |$M1$

$\Rightarrow t = \frac{\sqrt{1.47}}{(9.8\sin 30)}$ |$M1$

$\Rightarrow t = 0.247$ |$M1A1$

A148 - ID: 1955 *[16 marks, 19 minutes]*

(a) Forces at B $\Rightarrow 1.4g - T = 1.4 \times a$
$\Rightarrow T = 1.4g - 1.4a$ |$M1A1$
Forces at A $\Rightarrow T = 0.8a$ |$B1$
eliminate a $\Rightarrow T = 1.4g - 1.4\,\frac{T}{0.8}$
$\Rightarrow 2.75T = 1.4g$
$\Rightarrow T = 0.509g = 4.988\,N$ |$M1A1$
(b) $s = ut + \frac{1}{2}at^2 \Rightarrow 2.5 = \frac{1}{2}\,\frac{T}{0.8}t^2 = \frac{0.509g}{1.6}t^2$ |$M1$
$\Rightarrow t^2 = 0.8018924662202798$
$\Rightarrow t = 0.9$ |$M1A1$
(c) Forces at A $\Rightarrow T - \frac{1}{4}0.8g = 0.8a$ |$M1A1$
$\Rightarrow 0.8a = T - \frac{1}{4}0.8g$
$\Rightarrow 0.8a = 1.4g - 1.4a - \frac{1}{4}0.8g$ |$M1$
$\Rightarrow 2.2a = 1.2g$
$\Rightarrow a = 0.545g$ |$M1A1$
$s = ut + \frac{1}{2}at^2 \Rightarrow 2.5 = \frac{1}{2}(0.545g)t^2$ |$M1A1$
$\Rightarrow t^2 = \frac{5}{0.545g} \quad \Rightarrow t = 0.97$ |$A1$

A149 - ID: 1957 *[13 marks, 16 minutes]*

(a) For truck : $2600 - 500 - T = 1200a$ [1] |$M1$
For car : $T - 500 = 800a$ [2] |$M1$
[1] + [2] : $1600 = 2000a$
$\Rightarrow a = 0.8\,m/s^2$ |$A1$
(b) [2] $\Rightarrow T = 500 + 800a = 500 + 800 \times 0.8$ |$M1A1$
$\Rightarrow T = 1140Ns$ |$A1$
(c) if rope not broke: $v = u + at \Rightarrow 31 = 22 + 0.8t$
$\Rightarrow t = 11.25$ |$M2A1$
if rope broke: $2600 - 500 = 1200a$
$\Rightarrow a = 1.75$
$\Rightarrow 31 = 22 + 1.75t$
$\Rightarrow t = 5.14$ |$M2A1$
$\Rightarrow 11.25 - 5.14 = 6.11\,s$ earlier |$M1$

A150 - ID: 3158 *[14 marks, 17 minutes]*

(a)	At A :	$3mg\sin 29 - T = 3m.\frac{1}{6}g$	$M1A1$
		$\Rightarrow T = 0.954mg$	$A1$
(b)	At B :	$R = mg\cos 29$	$M1A1$
	:	$T - mg\sin 29 - F = m.\frac{1}{6}g$	$M1A2$
	$F = \mu R$	$\Rightarrow 0.954mg - mg\sin 29 - m.\frac{1}{6}g = \mu mg\cos 29$	$M2$
		$\Rightarrow \mu = 0.35$	$A1$
(c)	magnitude =	$2T\cos 61 = 0.925mg$	$M1A1$
	direction =	vertically downward	$B1$

A151 - ID: 7296 *[13 marks, 16 minutes]*

(a)	Car & trailer	$\Rightarrow 2070a = 2310 - 270 - 590$	$M1A1$
		$\Rightarrow a = 0.7\,ms^{-2}$	$A1$
(b)	For trailer	$\Rightarrow 780 \times 0.7 = T - 270$	$M1A1$
		$\Rightarrow T = 816\,N$	$A1$
(c)	For car	$\Rightarrow 1290a = 2310 - 590$	$M1A1$
		$\Rightarrow a = 1.333\,ms^{-2}$	$A1$
	Distance =	$15 \times 3 + \frac{1}{2}1.333 \times 3^2$	$M1A1$
		$= 51\,m$	$A1$
(d)	Inextensible	$\Rightarrow$ same acceleration for car and trailer	$B1$

A152 - ID: 530 *[16 marks, 19 minutes]*

(a)	A	$\Rightarrow T - 3g\sin 30 = 3a$	$M1A1$
	B	$\Rightarrow 5g - T = 5 \times a$	$M1A1$
(b)	solving	$\Rightarrow 5g - (3a + 3g\sin 30) = 5a$	
		$\Rightarrow 3.5g = 8a \Rightarrow a = 4.288\,ms^{-2}$	$M1A1$
(c)	T	$= 3a + 3g\sin 30 = 27.6\,N$	$M1A1$
(d)	strings inextensible	The accelerations of A and B are equal	$B1$
(e)	$v^2 = u^2 + 2as$	$\Rightarrow v^2 = 0 + 2 \times 4.288 \times 0.7 = 6$	$M1$
		$\Rightarrow v = 2.45$	$A1$
(f)	at A	$\Rightarrow -3g\sin 30 = 3a$	
		$\Rightarrow a = -4.9$	$M1A1$
	$s = ut + \frac{1}{2}at^2$	$\Rightarrow 0 = 2.45t + \frac{1}{2} - 4.9t^2$	$M1A1$
		$\Rightarrow t = 1\,s$	$A1$

A153 - ID: 2913 [4 marks, 5 minutes]

(a) Reason : string is light and pulley is smooth |B1

(b) Resolve ↕ at C $\Rightarrow T = 18g$

Resolve ↕ at F $\Rightarrow F = 25g - T = 7g\,N$ |M1A1

$\Rightarrow$ thrust |B1

A154 - ID: 2914 [7 marks, 8 minutes]

(a) $F = ma \Rightarrow P - 850N = 21800 \times 0.3$ |M1A1

$\Rightarrow P = 7390\,N$ |A1

(b) $F = ma \Rightarrow 7390 - 2650N = 21800a$

$\Rightarrow a = 0.217\,ms^{-2}$ |M1A1

(c) Resolve ↔ at A $\Rightarrow T - 2450 = 10900 \times 0.217$

$\Rightarrow T = 4820\,N$ |M1A1

A155 - ID: 2958 [10 marks, 12 minutes]

(a) At A : $4g - T = 4a$ |M1A1

At B : $T - 1.97g = 1.97a$ |A1

$\Rightarrow 4g - (1.97a + 1.97g) = 4a$

$\Rightarrow 2.03g = 5.97a$

$\Rightarrow a = 3.33\,ms^{-2}$ |M1A1

(b) $T = 1.97a + 1.97g = 25.87\,N$ |M1A1

(c) $s = 1 \Rightarrow v^2 = u^2 + 2as$ |M1

$\Rightarrow v^2 = 0 + 2 \times 3.33 \times 1$ |M1

$\Rightarrow v^2 = 6.66$

$\Rightarrow v = 2.58ms^{-1}$ |A1

A156 - ID: 7281 [17 marks, 20 minutes]

(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 2.352 = \frac{1}{2}a(1.4)^2$ |M1A1

$\Rightarrow a = 2.4\,ms^{-2}$ |A1

(b) Resolve ↕ for F : $0.4a = 0.4g - T$ |M1A1

$\Rightarrow T = 3\,N$ |A1

(c) Resolve ↕ for Q : $ma = T - mg$ |M1A1

$\Rightarrow m(2.4 + g) = T$

$\Rightarrow m = 0.24\,N$ |M1A1

(d) string inextensible : acceleration same for P and Q |B1

(e) speed of P when strikes ground $v = u + at = 2.4 \times 1.4 = 3.36\,s$ |M1A1

Speed for Q = $v = u + at$

$\Rightarrow 3.36 = -3.36 + 9.8t$ |M1A1

$\Rightarrow t = 0.69\,s$ |M1A1

A157 - ID: 7770 [6 marks, 7 minutes]

(a) for the caravan $f = ma \Rightarrow T - 800 = 950 \times 0.7$ |M1A1

$\Rightarrow T = 1465\,N$ |A1

(b) for car & caravan $f = ma \Rightarrow D - 470 - 800 = 2460 \times 0.7$ |M1A1

$\Rightarrow D = 2992\,N$ |A1

A158 - ID: 2889 [15 marks, 18 minutes]

(a) Forces at B $\Rightarrow 2mg - T = \frac{3}{8}g \times 2m$ |M1A1

$\Rightarrow T = \frac{10}{8}mg$ |A1

(b) Forces at A $\Rightarrow T - \mu mg = \frac{3}{8}g \times m$ |M1A1

$\Rightarrow \frac{10}{8}mg = \frac{3}{8}mg + \mu mg$ |M1A1

$\Rightarrow \frac{10}{8} = \frac{3}{8} + \mu$

$\Rightarrow \mu = \frac{7}{8}$ |A1

(c) $v^2 = u^2 + 2as \Rightarrow v^2 = 0 + 2 \times \frac{3}{8}g \times h = \frac{6}{8}gh$ |M1A1

deceleration of A $ma = \mu \times mg$

$\Rightarrow a = \mu g$ |M1A1

At P $v^2 = u^2 + 2as = \frac{6}{8}gh - 2\mu g \times \frac{1}{4}h$

$= \frac{6}{8}gh - \frac{14}{32}gh = \frac{10}{32}gh$

$\Rightarrow v = \sqrt{\frac{10}{32}gh}$ |M1A1

(d) comment $\Rightarrow$ same tension on A and B |B1

A159 - ID: 2907 [8 marks, 10 minutes]

(a) Resolve $\updownarrow$ at sphere $\Rightarrow mg = 56.2 \Rightarrow m = 5.7\,kg$ |M1A1

(b) Resolve $\leftrightarrow$ at block $\Rightarrow F = 56.2\cos 30 \Rightarrow F = 48.7\,N$ |B1M1A1

(c) Resolve $\updownarrow$ at block $\Rightarrow R + 56.2\sin 30 = 19g$ |M1A1

$\Rightarrow R = 186.2 - 56.2\sin 30 = 158.1\,N$ |A1

A160 - ID: 4578 *[14 marks, 17 minutes]*

(a) $F = ma \Rightarrow -150 = 250a$ |$M1$

$\Rightarrow a = -0.6\,ms^{-2}$ |$A1$

(b) $F = ma \Rightarrow 900 \times -0.6 = D - 600$ |$M1$

$\Rightarrow D = 60\,N$ |$M1A1$

(c) $v^2 = u^2 + 2as \Rightarrow 15^2 = 18^2 + 2 \times -0.6 \times s$ |$M1$

$\Rightarrow s = 82.5\,m$ |$A1$

(d) $F = ma \Rightarrow 1150a = 980 + 1150g\sin 3 - 750$ |$M1A2$

$\Rightarrow a = 0.713\,ms^{-2}$ |$A1$

(e) $F = ma \Rightarrow 250a = P + 250g\sin 3 - 150$ |$M1A1$

$\Rightarrow P = 200\,N$ |$A1$

A161 - ID: 5555 *[15 marks, 18 minutes]*

(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 7 = 0 + \frac{1}{2}a5^2$

$\Rightarrow a = \frac{14}{25}ms^{-2}$ |$M1A1$

(b) $N2L \Rightarrow 26 - \mu 7g = 7a$ |$M1A1$

$\Rightarrow \mu = 0.322$ |$M1A1$

(c) $N2L$ for P $\Rightarrow T - \mu 4g = 4a$ |$M1A1$

$\Rightarrow T = 14.857\,N$ |$M1A1$

(d) comment $\Rightarrow$ The acceleration of P and Q is the same. |$B1$

(e) $v = u + at \Rightarrow v = 2.8$ |$B1$

$N2L$ for system $\Rightarrow -7\mu g = 7a$

$\Rightarrow a = -\mu g$ |$M1$

$v = u + at \Rightarrow 0 = 2.8 - \mu gt$

$\Rightarrow t = 0.888$ |$M1A1$

A162 - ID: 7310 *[8 marks, 10 minutes]*

(a) Forces at B $\Rightarrow 5g - T = 5 \times 0.9$ |$M1A1$

$\Rightarrow T = 44.5\,N$ |$A1$

(b) magnitude $= 6g$ |$B1$

(c) forces at A $\Rightarrow T - F = 6 \times 0.9$

$\Rightarrow 44.5 - F = 6 \times 0.9$

$\Rightarrow F = 39.1$ |$M1A1$

(d) $\mu = \frac{F}{R} = \frac{39.1}{6g} = 0.665$ |$M1A1$

A163 - ID: 7330 *[15 marks, 18 minutes]*

(a) For P, $s = ut + \frac{1}{2}at^2 \Rightarrow s = \frac{1}{2} \times 1 \times 0.5^2 = 0.125\,m$ |$M1A1$

$v = u + at = 1 \times 0.5 = 0.5\,ms^{-1}$ |$M1A1$

(b) For Q $v^2 = u^2 + 2as \Rightarrow 0 = 0.5^2 - 2gs$

$\Rightarrow s = 0.013\,m$ |$M1A1$

$v = u + at \Rightarrow 0 = 0.5 - gt$

$\Rightarrow t = 0.051\,s$ |$M1$

$\Rightarrow$ total time $= 0.551\,s$ |$A1$

(c) For P $force = ma \Rightarrow m_P g - 5.92 = m_P \times 1$

$\Rightarrow m_P = 0.673\,kg$ |$M1A1$

For Q $force = ma \Rightarrow 5.92 - m_Q g = m_Q \times 1$

$\Rightarrow m_Q = 0.548\,kg$ |$M1A1$

(d) tension $= 0.4g + 2 \times 5.92 = 15.76\,N$ |$M1A1$

(e) tension $= 0.4g = 3.92\,N$ |$B1$

A164 - ID: 7337 *[16 marks, 19 minutes]*

(a) Normal reaction $= 0.4g\cos 45 = 2.772\,N$ |$M1$

friction force $= 1 \times N = 2.772\,N$ |$A1$

(b) $force = ma \Rightarrow 0.8a = 0.8g\sin 45 - 2.772$ |$M1A1$

$\Rightarrow a = 3.465\,ms^{-2}$ |$A1$

For $Q \Rightarrow 0.4a = T + 0.4g\sin 45 - 2.772$ |$M1$

$\Rightarrow T = 1.386\,N$ |$A1$

(c) For Q $s = 0.8 \Rightarrow v^2 = u^2 + 2as$

$\Rightarrow v^2 = 0 + 2 \times 3.465 \times 0.8 = 5.544$

$\Rightarrow v = 2.35\,ms^{-1}$ |$M1A1$

(d) For Q, $force = ma \Rightarrow 0.4a = 0.4g\cos sin45 - 2.772 = 0$

$\Rightarrow a = 0 \Rightarrow$ constant velocity |$M1A1$

time for Q $= 4 \div 2.35 = 1.7$ |$B1$

time for P $\Rightarrow s = ut + \frac{1}{2}at^2$

$\Rightarrow 3.2 = 2.35t + \frac{1}{2}gsin45t^2$

$\Rightarrow 3.46t^2 + 2.35t - 3.2 = 0$ |$M1A1$

$\Rightarrow t = 0.68$ |$A1$

$\Rightarrow$ time interval $= 1.02\,s$ |$A1$

A165 - ID: 7390 *[6 marks, 7 minutes]*

For P $force = ma \Rightarrow T - 3g = 3a$ | $M1B1$
For Q $force = ma \Rightarrow 6g - T = 6a$ | $A1$
$\Rightarrow 6g - (3a + 3g) = 6a$
$\Rightarrow 3g = 9a$
$\Rightarrow a = 3.27\,ms^{-2}$ | $M1A1$
$\Rightarrow T = 3a + 3g = 39.2\,N$ | $A1$

A166 - ID: 7399 *[8 marks, 10 minutes]*

(a) Forces on $m\,kg$ bo$\Rightarrow T = ma$ | $M1A1$
Forces on $5m\,kg$ bo$\Rightarrow 5mg - T = 5ma$ | $M1A1$
$\Rightarrow 5mg - ma = 5ma$
$\Rightarrow 5mg = 6ma$
$\Rightarrow a = \frac{5g}{6}\,ms^{-2}$ | $A1$

(b) $v = u + at \Rightarrow 2u = u + \frac{5g}{6}S$ | $M1A1$
$\Rightarrow u = \frac{5g}{6}S \Rightarrow S = \frac{6u}{5g}$ | $A1$

A167 - ID: 7407 *[12 marks, 14 minutes]*

(a) For P, $force = ma \Rightarrow T - 5g = 5a$ | $M1A1$
For Q, $force = ma \Rightarrow 8g - T = 8a$ | $M1A1$
$\Rightarrow 8g - 5g = 13a$
$\Rightarrow a = 2.262\,ms^{-2}$ | $M1A1$
$\Rightarrow T = 5g + 11.308 = 60.308\,N$ | $A1$

(b) For P $v = u + at \Rightarrow 0 = 0.6 - gt$
$\Rightarrow t = 0.061\,s$ | $M1A1$
$s = ut + \frac{1}{2}at^2 = 0.6(0.061) - \frac{1}{2}g(0.061)^2 = 1.84\,cm$ | $M1$

A168 - ID: 5715 *[16 marks, 19 minutes]*

(a) $T - 6g\sin\alpha = 6a$ | $M1A1$
$11g - T = 11a$ | $M1A1$
$\Rightarrow 11g - 6g\sin\alpha = 17a$
$\Rightarrow a = 0.44g$ | $M1A1$

(b) $T = 6a + 6g\sin\alpha = 6.21g$ | $M1A1$

(c) for Q $\Rightarrow 3g - N = 3a$ | $M1A1$
$\Rightarrow N = 1.694\,g$ | $A1$

(d) $F = 2T\cos\frac{90-\alpha}{2}$ | $M1A2$
$= 12.42g\cos 26.57 = 108.9\,N$ | $M1A1$

A169 - ID: 6976 [13 marks, 16 minutes]

(a) Whole system $\Rightarrow 1000 - 400 - 200 = 1000a$ | $M1A1$

$\Rightarrow a = 0.4$ | $A1$

(b) For trailer $\Rightarrow T - 200 = 240 \times 0.4$ | $M1A1$

$\Rightarrow T = 296\,N$ | $A1$

(c) For trailer $\Rightarrow 200 + 90 = 240f$ | $M1A1$

$\Rightarrow f = 1.208\,ms^{-2}$ | $A1$

For the car $\Rightarrow 400 + F - 90 = 760f$ | $M1A2$

$\Rightarrow F = 608.33\,N$ | $A1$

A170 - ID: 7318 [14 marks, 17 minutes]

(a) assumption : the pulley is smooth | $B1$

(b) assumptions : the string is light and inextensible | $B2$

(c) For A : $T - 8g = 8a$ | $M1A1$

For B : $10g - T = 10a$ | $M1A1$

$\Rightarrow 2g = 18a$

$\Rightarrow a = 1.09\,ms^{-2}$ | $A1$

(d) $v = u + at \Rightarrow v = 0 + 1.09 \times 0.8 = 0.87\,ms^{-1}$ | $M1A1$

(e) $s = ut + \frac{1}{2}at^2 \Rightarrow s = \frac{1}{2}1.09 \times 0.64 = 0.3484\,m$ | $M1A1$

$\Rightarrow d = 2 \times s = 0.697\,m$ | $M1A1$

A171 - ID: 7340 [9 marks, 11 minutes]

(a) for car and trailer $force = ma \Rightarrow D - 880 - 370 = 1760 \times 0$ | $M1$

$\Rightarrow D = 1250\,N$ | $A1$

for trailer $force = ma \Rightarrow T - 370 = 460 \times 0$

$\Rightarrow T = 370\,N$ | $A1$

(b) for car and trailer $force = ma \Rightarrow D - 880 - 370 = 1760 \times 0.3$ | $M1A1$

$\Rightarrow D = 1778\,N$ | $A1$

for trailer $force = ma \Rightarrow T - 370 = 460 \times 0.3$ | $M1A1$

$\Rightarrow T = 508\,N$ | $A1$

A172 - ID: 7765 [9 marks, 11 minutes]

(a) $v^2 = u^2 + 2as \Rightarrow 14^2 = 0 + 2 \times 1.5 \times s0$ | $M1A1$

$\Rightarrow s = 65.3\,m$ | $A1$

(b) for car and trailer $force = ma \Rightarrow 3730 - 800 - P = 1920 \times 1.5$ | $M1A1$

$\Rightarrow P = 50\,N$ | $A1$

(c) for trailer $force = ma \Rightarrow T - 50 = 700 \times 1.5$ | $M1A1$

$\Rightarrow T = 1100\,N$ | $A1$

A173 - ID: 7300 [14 marks, 17 minutes]

(a) For P_1 : $7mg - T = 7m\frac{1}{4}g$ |M1A1

$\Rightarrow T = \frac{21}{4}mg$ |A1

(b) For P_2 : $T - kmg = km\frac{1}{4}g$ |M1A1

$\Rightarrow \frac{21}{4}mg - kmg = km\frac{1}{4}g$

$\Rightarrow \frac{21}{4} = k\frac{5}{4}$

$\Rightarrow k = 4.2$ |A1

(c) smooth : acceleration same for both particles |B1

(d) For P_1, $v = u + at \Rightarrow v = 0 + \frac{1}{4}g \times 1.8 = 4.41$ |M1A1

$s = ut + \frac{1}{2}at^2 \Rightarrow s = 0 + \frac{1}{8}g(1.8)^2 = 3.969$ |M1A1

For P_2, $v^2 = u^2 + 2as \Rightarrow 0 = 4.41^2 - 2gs$

$\Rightarrow s = 0.992$ |M1A1

$\Rightarrow$ greatest height $= 2 \times 3.969 + 0.992$

$= 8.93m$ |A1

A174 - ID: 855 [11 marks, 13 minutes]

(a) $\underline{F} = (5 + 4)\,\underline{i} + (3 - 7)\underline{j}$

$= (9\underline{i} - 4\underline{j})N$ |B1

(b) Angle $= 90 + \tan^{-1}\frac{4}{9}$ |M1

$= 90 + 24$ |A1

$= 114°$ |A1

(c) $F = ma \Rightarrow (9\underline{i} - 4\underline{j}) = 6\underline{a}$ |M1

$\Rightarrow \underline{a} = (1.5\underline{i} - 0.667\underline{j})ms^{-2}$ |A1

(d) $\underline{v} = \underline{u} + \underline{a}t \Rightarrow \underline{v} = (-2\underline{i} + 3\underline{j}) + 3(1.5\underline{i} - 0.667\underline{j})$ |M1

$\Rightarrow \underline{v} = (2.5\underline{i} + 1\underline{j})$ |M1A1

$\Rightarrow$ speed $= \sqrt{2.5^2 + 1^2} = 2.69ms^{-1}$ |M1A1

A175 - ID: 892 [7 marks, 8 minutes]

(a) $F = ma \Rightarrow 3\underline{i} - 9\underline{j} = 3a$

$\Rightarrow a = (1\underline{i} - 3\underline{j})N$ |M1

$\Rightarrow |a| = \sqrt{1^2 + 3^2}$ |M1

$\Rightarrow |a| = 3.16$ |M1A1

(b) $\underline{v} = \underline{u} + \underline{a}t \Rightarrow \underline{v} = (2\underline{i} + 2\underline{j}) + 2(1\underline{i} - 3\underline{j})$ |M1

$\Rightarrow \underline{v} = 4\underline{i} - 4\underline{j}$ |M1A1

A176 - ID: 509 [6 marks, 7 minutes]

(a) $v = u + at \Rightarrow (-14\underline{i} + 18\underline{j}) = (7\underline{i} - 23\underline{j}) + 2(a\underline{i} + b\underline{j})$ |$M1$

$(\underline{i}) \Rightarrow -14 = 7 + 2a \Rightarrow a = -10.5$ |$A1$

$(\underline{j}) \Rightarrow 18 = -23 + 2b \Rightarrow b = 20.5$

$\text{acc} = (-10.5\underline{i} + 20.5\underline{j})$ |$A1$

(b) $F = Ma \Rightarrow F = 0.3(-10.5\underline{i} + 20.5\underline{j})\ N$ |$M1$

$\Rightarrow F = (-3.15\underline{i} + 6.15\underline{j})N$ |$A1$

$\Rightarrow \text{magnitude} = \sqrt{-3.15^2 + 6.15^2} = 6.91\,N$ |$A1$

A177 - ID: 1948 [14 marks, 17 minutes]

(a) at greatest height $v^2 = u^2 + 2as \Rightarrow 0 = u^2 + 2(-g)26.7$ |$M1A1$

$\Rightarrow u^2 = 523.32$

$\Rightarrow u = 22.876$ |$A1$

(b) at greatest height, $v = u + at \Rightarrow 0 = 22.876 - 9.8t$

$\Rightarrow t = 2.334$ |$M1$

at ground, $s = ut + \frac{1}{2}at^2 \Rightarrow 28.3 = \frac{1}{2}9.8t^2$

$\Rightarrow t^2 = 5.776$ |$M1$

$\Rightarrow t = 2.403$

$\Rightarrow T = 2.334 + 2.403 = 4.74$ |$M1A1$

(c) at ground $v^2 = u^2 + 2as \Rightarrow v^2 = 2.g.28.3$

$\Rightarrow v^2 = 554.68$

$\Rightarrow v = 23.552$ |$M1A1$

when stopped $v^2 = u^2 + 2as \Rightarrow 0 = 23.552^2 - 2a.0.028$

$\Rightarrow a = 9905.298$ |$M1A1$

forces on particle $\Rightarrow 0.7g - F = 0.7a$ |$M1$

$\Rightarrow F = 6940\,N$ (3 sf) |$A1$

(d) factor = wind resistance or spin |$B1$

A178 - ID: 712 [9 marks, 11 minutes]

(a) $v = u + at \Rightarrow 11\underline{i} - 5\underline{j} = 3\underline{i} + 5\underline{j} + 2a$

$\Rightarrow a = 4\underline{i} - 5\underline{j}$ |$M1A1$

(b) $F = ma \Rightarrow F = 2(4\underline{i} - 5\underline{j}) = (8\underline{i} - 10\underline{j})$ |$M1A1$

$\Rightarrow |F| = \sqrt{8^2 + 10^2} = 12.81\,N$ |$M1A1$

(c) $t = 5 \Rightarrow v = u + at$

$\Rightarrow v = (3\underline{i} + 5\underline{j}) + 5(4\underline{i} - 5\underline{j})$ |$M1A1$

$\Rightarrow v = (23\underline{i} - 20\underline{j})ms^{-1}$ |$A1$

A179 - ID: 2916 *[8 marks, 10 minutes]*

(a) $F = ma \Rightarrow -89\underline{k} + (-2\underline{i} + 20\underline{j} + 72\underline{k}) = 5a$ |$M1$

$\Rightarrow a = (-0.4\underline{i} + 4\underline{j} - 3.4\underline{k})\ ms^{-2}$ |$A1$

(b) $s = ut + \frac{1}{2}at^2 = 3(2\underline{i} + -6\underline{j} + 4\underline{k}) + \frac{9}{2}(-0.4\underline{i} + 4\underline{j} - 3.4\underline{k})$ |$M1A1$

$= (6\underline{i} + -18\underline{j} + 12\underline{k}) + (-1.8\underline{i} + 18\underline{j} - 15.3\underline{k})$

$= (4.2\underline{i} + 0\underline{j} + -3.3\underline{k})$ |$A1$

(c) $OA = \sqrt{4.2^2 + 0^2 + -3.3^2} = \sqrt{28.53}$ |$A1$

(d) angle $= \tan^{-1}\frac{-3.3}{4.2} = -38.16°$ |$M1A1$

A180 - ID: 7773 *[8 marks, 10 minutes]*

(a) $f = ma \Rightarrow 93g\sin 5 - P = 0$ |$M2$

$\Rightarrow P = 79.4\,N$ |$A1$

(b) $f = ma \Rightarrow 93g\sin 7 - 79.4 = 93a$ |$M1A2$

$\Rightarrow a = 0.341\,ms^{-2}$ |$A1$

(c) *comment* $\Rightarrow P$ would vary with speed of trolley |$B1$

A181 - ID: 2905 *[7 marks, 8 minutes]*

(a) $F = ma \Rightarrow \begin{pmatrix} 9 \\ 6 \end{pmatrix} = 1.2a \Rightarrow a = \begin{pmatrix} 7.5 \\ 5 \end{pmatrix} ms^{-2}$ |$M1A1$

(b) angle $= \tan^{-1}\frac{5}{7.5} = 33.7°$ |$M1A1$

(c) $s = ut + \frac{1}{2}at^2 = 5\begin{pmatrix} -8 \\ 5 \end{pmatrix} + \frac{25}{2}\begin{pmatrix} 7.5 \\ 5 \end{pmatrix}$ |$M1A1$

$= \begin{pmatrix} -40 \\ 25 \end{pmatrix} + \begin{pmatrix} 93.75 \\ 62.5 \end{pmatrix} = \begin{pmatrix} 53.75 \\ 87.5 \end{pmatrix} m$ |$A1$

A182 - ID: 2909 *[17 marks, 20 minutes]*

(a) $v = u + at \Rightarrow 3.1 = 0.8 + 1.8t$

$\Rightarrow t = 1.278\,s$ |$M1A1$

$s = \frac{1}{2}(u + v)t = \frac{1}{2}(0.8 + 3.1) \times 1.278 = 2.492\,m$ |$M1A1$

(b) (i) Resolve $\updownarrow \Rightarrow 76g - T = 76 \times 1.8$ |$M1A1$

$\Rightarrow T = 608\,N$ |$A1$

(ii) Resolve $\updownarrow \Rightarrow 76g - T = -76 \times 1.8$

$\Rightarrow T = 881.6\,N$ |$M1A1$

(c) Resolve $\updownarrow \Rightarrow T - 76g - 127 = 76a$ |$M1A1$

$\Rightarrow 76g + 127 + 76a < 1900$

$\Rightarrow a < 13.5\,ms^{-2}$ *upwards* |$M1A1$

(d) Resolve $\updownarrow$ for equipment $\Rightarrow 83 - 9g = 9a$

$\Rightarrow a = -0.578\,ms^{-2}$ |$M1A1$

Resolve $\updownarrow$ for man $\Rightarrow T - 76g - 83 - 127 = 76 \times -0.578$

$\Rightarrow T = 910.9\,N$ |$M1A1$

A183 - ID: 3302 *[8 marks, 10 minutes]*

(a) angle $= \tan^{-1}\frac{9}{7} = 52.1°$ | $M1A1$

(b) $F = ma \Rightarrow F = 0.3(7i + 9j)$

$\Rightarrow F = (2.1i + 2.7j)\ N$ | $M1A1$

$\Rightarrow |F| = \sqrt{2.1^2 + 2.7^2} = 3.4\,N$ | $A1$

(c) $v = u + at = 9i–10j + 5(7i + 9j) = 44i + 35j$ | $M1A2$

A184 - ID: 4574 *[4 marks, 5 minutes]*

$75g - F = -75 \times 0.7 \Rightarrow F = 75g + 75 \times 0.7$ | $M1A1$

$\Rightarrow F = 735 + 52.5 = 787.5\,N$ | $M1A1$

A185 - ID: 5459 *[8 marks, 10 minutes]*

(a) $930 - 90g = 90a$ | $B1M1$

$\Rightarrow a = 0.533\,ms^{-2}$ | $A1$

(b) $T - 90g = 54 \Rightarrow T = 936\,N$ | $M1A1$

(c) $T\cos 23 - 90g = 54 \Rightarrow T = 1016.8\,N$ | $M1A2$

A186 - ID: 5460 *[5 marks, 6 minutes]*

(a) force $= 7 \times \begin{pmatrix}-5\\3\end{pmatrix} = \begin{pmatrix}-35\\21\end{pmatrix} N$ | $M1A1$

(b) position vector $= \begin{pmatrix}-2\\5\end{pmatrix} + ut + \frac{1}{2}at^2$

$= \begin{pmatrix}-2\\5\end{pmatrix} + 4\begin{pmatrix}6\\6\end{pmatrix} + \frac{1}{2}16\begin{pmatrix}-5\\3\end{pmatrix}$ | $M1A1$

$= \begin{pmatrix}-18\\53\end{pmatrix}$ | $B1$

A187 - ID: 5462 *[4 marks, 5 minutes]*

for both boxes together $\Rightarrow 134 - 6 = (3 + 7)a$ | $M1$

$\Rightarrow a = 12.8\,ms^{-2}$ | $A1$

for box A $\Rightarrow T - 6 = 3 \times 12.8$ | $M1$

$\Rightarrow T = 44.4\,N$ | $A1$

A188 - ID: 7301 *[6 marks, 7 minutes]*

(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 7 = 0 + \frac{1}{2}a(4)^2$ | $M1$

$\Rightarrow a = 0.88\,ms^{-2}$ | $A1$

(b) $force = ma \Rightarrow T - 63g = 63 \times 0.88$ | $M1A1$

$\Rightarrow T = 672.53\,N$ | $A1$

(c) average speed $= 7 \div 4 = 1.75ms^{-1}$ | $A1$

A189 - ID: 7332 *[6 marks, 7 minutes]*

(a) $force = ma \Rightarrow 640 - 250 = 870a$

$\Rightarrow a = 0.45\,ms^{-2}$ |$M1A1$

(b) $v = u + at \Rightarrow 5 = 2 + 0.45t$

$\Rightarrow t = 6.69\,s$ |$M1A1$

$v^2 = u^2 + 2as \Rightarrow 5^2 = 2^2 + 2 \times 0.45 \times s$

$\Rightarrow s = 23.42\,m$ |$M1A1$

A190 - ID: 7389 *[6 marks, 7 minutes]*

(a) for the lift and man $force = ma \Rightarrow 477g - 4650 = 477a$ |$M1A1$

$\Rightarrow a = 0.05\,ms^{-2}$ |$A1$

(b) for the man $force = ma \Rightarrow 67g - R = 67 \times 0.05$ |$M1A1$

$\Rightarrow R = 653.14\,N$ |$A1$

A191 - ID: 7403 *[8 marks, 10 minutes]*

(a) $force = ma \Rightarrow 3160 - 2170 = 480a$ |$M1A1$

$\Rightarrow a = 2.06\,ms^{-2}$ |$A1$

(b) $s = ut + \frac{1}{2}at^2 \Rightarrow 150 = 7u + \frac{1}{2} \times 2.06(7)^2$ |$M1A1$

$\Rightarrow 7u = 150 - 50.53$

$\Rightarrow u = 14.21\,ms^{-1}$ |$A1$

(c) $v = u + at = 14.21 + 14.44 = 28.65\,ms^{-1}$ |$M1A1$

A192 - ID: 7317 *[7 marks, 8 minutes]*

(a) $force = ma \Rightarrow 4a = 4g\sin 41$ |$M1A1$

$\Rightarrow a = g\sin 41 = 6.4\,ms^{-2}$ |$A1$

(b) $s = ut + \frac{1}{2}at^2 \Rightarrow 0.5 = 0 + \frac{1}{2}a(0.4)^2$ |$M1A1$

$\Rightarrow 0.5 = 0.08a$

$\Rightarrow a = 6.2\,ms^{-2}$ |$A1$

(c) less because: of friction or air resistance |$B1$

A193 - ID: 7326 [10 marks, 12 minutes]

(a) resultant $= 4.4i + 12j$ | $M1A1$

(b) magnitude $= \sqrt{4.4^2 + 12^2} = 12.8\,N$ | $M1A1$

(c) $force = ma \Rightarrow 4.4i + 12j = m(1.1i + 3j)$

$\Rightarrow m = 4\,kg$ | $M1A1$

(d) $s = ut + \frac{1}{2}at^2 \Rightarrow r = \frac{1}{2}(1.1i + 3j)t^2$ | $M1A1$

(e) $t = 3 \Rightarrow r = 4.5(1.1i + 3j) = 4.95i + 13.5j$

$\Rightarrow$ distance $= \sqrt{4.95^2 + 13.5^2} = 14.4$ | $M1A1$

A194 - ID: 7356 [5 marks, 6 minutes]

(a) $force = ma$ for the parcel $\Rightarrow 39 - 3g = 3a$ | $M1A1$

$\Rightarrow a = 3.2\,ms^{-2}$ | $A1$

(b) $force = ma$ for the man $\Rightarrow R - 78g - 39 = 78 \times 3.2$

$\Rightarrow R = 1053\,N$ | $M1A1$

A195 - ID: 7358 [15 marks, 18 minutes]

(a) Friction force, $F = 122\cos 31 = 105\,N$ | $M1A1$

(b) Normal reaction, $N = 93g - 122\sin 31$ | $M1B1$

$= 848.6\,N$ | $A1$

(c) motion = continues at constant speed $0.4\,ms^{-1}$ | $B2$

(d) $force = ma \Rightarrow 150\cos 31 - 99 = 93a$ | $M1A1$

$\Rightarrow a = 0.318\,ms^{-2}$ | $A1$

(e) $v = u + at \Rightarrow 3 = 0 + 2a$

$\Rightarrow a = 1.5\,ms^{-2}$ | $M1A1$

$force = ma \Rightarrow 93g\sin 28 - F = 93 \times 1.5$ | $M1B1$

$\Rightarrow F = 288.4\,N$ | $A1$

A196 - ID: 7763 [6 marks, 7 minutes]

(a) $F = ma \Rightarrow F = 320 \times 2.4 = 768\,N$ | $B1$

(b) $P - 440 = 768 \Rightarrow P = 1208\,N$ | $M1A1$

(c) $v = u + at \Rightarrow 20 = 13 + 2.4t$ | $M1A1$

$\Rightarrow t = \dfrac{20 - 13}{2.4} = 2.9\,s$ | $A1$

A197 - ID: 746 *[6 marks, 7 minutes]*

(a) Resolving $\updownarrow$: $R_C + R_D = 95$ | $M1$

$R_C = 25 \Rightarrow R_D = 70$ | $A1$

(b) Moments at A : $R_C \times 0.9 + R_D \times x = 95 \times 4.5$ | $M2$

$\Rightarrow 25 \times 0.9 + 70x = 427.5$ | $A1$

$\Rightarrow 22.5 + 70x = 427.5$

$\Rightarrow x = 5.786m.$ | $A1$

A198 - ID: 691 *[8 marks, 10 minutes]*

(a) moments at A : $R_C \times 3 = 80 \times \frac{x}{2} + 20 \times x$ | $M1$

$\Rightarrow 300 = 60x$ | $M1$

$\Rightarrow x = 5m.$ | $M1A1$

(b) $R_C + R_D = 80 + 20 \Rightarrow 4R_D = 100$

$\Rightarrow R_D = 25$ | $M1A1$

moments at A : $R_C \times 3 + R_D \times AD = 80 \times \frac{5}{2} + 20 \times 5$ | $M1$

$\Rightarrow 3R_D \times 3 + R_D \times AD = 300$

$\Rightarrow 225 + 25AD = 300$

$\Rightarrow AD = 3m$ | $A1$

A199 - ID: 717 *[6 marks, 7 minutes]*

(a) ($\updownarrow$) $R + R = 50 + 75$ | $M1$

$\Rightarrow R = 62.5N$ | $A1$

(b) moments at A $\Rightarrow 4 \times 62.5g = (50g \times 3.5) + (75g \times x)$ | $M1A1$

$\Rightarrow 250 = 175 + 75x$

$\Rightarrow x = 1m.$ | $M1A1$

A200 - ID: 871 *[10 marks, 12 minutes]*

(a) Resolving $\Rightarrow R_C + R_D = 110 + W$

$\Rightarrow 3R_D = 110 + W \Rightarrow R_D = \frac{110+W}{3}$ | $M1A1$

moments at A $\Rightarrow 0.3 \times R_C + 4 \times R_D = 110 \times 3 + W \times x$

$\Rightarrow 4.6R_D = 330 + Wx$

$\Rightarrow R_D = \frac{330+Wx}{4.6}$ | $M1A1$

$\Rightarrow \frac{110+W}{3} = \frac{330+Wx}{4.6}$

$\Rightarrow 505.99999999999994 + 4.6W = 990 + 3Wx$ | $M1A1$

$\Rightarrow (4.6 - 3x)W = 484$

$\Rightarrow W = \frac{484}{4.6-3x}$ | $M1A1$

(b) $W > 0 \Rightarrow 4.6 - 3x > 0 \Rightarrow x < 1.5333333333333332$ | $M1A1$

A201 - ID: 3073 [10 marks, 12 minutes]

(a) moments at A $\Rightarrow 9g \times 4 = R \times 6$ | $M1A1$
$\Rightarrow R = 58.8\,N$ | $A1$
(b) $(\updownarrow)$ $R + R = 9g + 40g$ | $M1$
$\Rightarrow R = 24.5g\,N$ | $A1$
moments at A $\Rightarrow 9g \times 4 + 40g \times AD = 24.5g \times 6$ | $M1A2$
$\Rightarrow 40gAD = 111g$
$\Rightarrow AD = 2.775\,m$ | $M1A1$

A202 - ID: 7295 [13 marks, 16 minutes]

(a) Resolve $\updownarrow \Rightarrow T_A + 2T_A = 216$
$\Rightarrow T_A = 72$ | $M1A1$
(b) moments at A $\Rightarrow T_C \times 69 = 216 \times x$
$\Rightarrow 2 \times 72 \times 69 = 216 \times x$ | $M1A1$
$\Rightarrow x = 46$
$\Rightarrow AB = 2 \times 46 = 92\,cm$ | $M1A1$
(c) Resolve $\updownarrow \Rightarrow T_A + 4T_A = 216 + W$
$\Rightarrow 5T_A = 216 + W$ | $M1A1$
moments at A $\Rightarrow 4T_A \times 69 = 216 \times 46 + W \times 92$ | $M1A2$
$\Rightarrow \frac{276}{5}(216 + W) = 9936 + 92W$
$\Rightarrow 59616 + 276W = 49680 + 460W$
$\Rightarrow 9936 = 184W$
$\Rightarrow W = 54\,N$ | $M1A1$

A203 - ID: 3260 [5 marks, 6 minutes]

moments at A $\Rightarrow T_C \times 3 = 30g \times 2.5$ | $M1A1$
$\Rightarrow T_C = 25g\,N$ | $A1$
$(\updownarrow)$ $T_A + T_C = 30g \Rightarrow T_A = 5g\,N$ | $M1A1$

A204 - ID: 3269 [9 marks, 11 minutes]

(a) moments at C $\Rightarrow 14g \times 5 = 47g \times x$ | $M1A1$
$\Rightarrow x = 1.489\,m$ | $A1$
(b) moments at C $\Rightarrow 14g \times 5 + Mg \times 13 = 47g \times 3$ | $M1A1$
$\Rightarrow M = 5.462\,kg$ | $M1A1$
(c) assumption : centre of mass is at centre of rod | $B1$
(d) assumption : woman is a particle
or mass is a particle
or plank is rigid | $B1$

A205 - ID: 7275 *[9 marks, 11 minutes]*

(a) moments at C $\Rightarrow 0.15 \times 8g = (0.3 \times m)g$ |$M1A1$

$\Rightarrow 1.2 = 0.3m$

$\Rightarrow m = 4\,m$ |$M1A1$

(b) moments at D $\Rightarrow AD \times 7g = (0.45 - AD) \times 8g + (0.9 - AD) \times 4g$ |$M1A2$

$\Rightarrow 7AD = 3.6 - 8AD + 3.6 - 4AD$

$\Rightarrow 19AD = 7.2$

$\Rightarrow AD = 0.38m$ |$M1A1$

A206 - ID: 2887 *[11 marks, 13 minutes]*

(a) moments at A $\Rightarrow 12g \times 2 = T_C \times 2.6$ |$M1A1$

$\Rightarrow T_C = 9.2g$ |$A1$

(b) $12g = T_A + T_C$

$\Rightarrow T_A = 2.769g$ |$M1A1$

(c) moments at A $\Rightarrow 12g \times 2 + 19g \times y = T_C \times 2.6$ |$M1A1$

$\Rightarrow T_C = 9.23076923076923g + 7.308gy$ |$A1$

(d) $T_C \leq 91N \Rightarrow 9.23076923076923g + 7.308gy \leq 91N$ |$M1A1$

$\Rightarrow 7.308gy \leq 0.538$

$\Rightarrow y \leq 0.008\,m$ |$A1$

A207 - ID: 3304 *[10 marks, 12 minutes]*

(a) moments at A $\Rightarrow 16g \times 1.15 + 8g \times 0.5 = T_B \times 2.3$ |$M1A1$

$\Rightarrow T_B = 9.7g$ |$M1A1$

(b) Resolve vertically $\Rightarrow T_A + T_B = 16g + 8g$

$T_A = T_B + 13 \Rightarrow (T_B + 13) + T_B = 24g$

$\Rightarrow T_B = 111.1\,N$ |$M1A1$

moments at A $\Rightarrow 16g \times x + 8g \times 0.5 = T_B \times 2.3$ |$M1A1$

$\Rightarrow 16g \times x + 4g = 255.53$

$\Rightarrow x = 1.38\,m$ |$M1A1$

A208 - ID: 5713 [13 marks, 16 minutes]

(a) Resolve vertically $= R_Q + R_R = 18 + 62 + 26 = 106g$ |$M1A1$

moments at Q $\Rightarrow 26g \times 0.3 + R_R \times 2.2 = (18 + 62)g \times 1.1$ |$M1A1$

$\Rightarrow R_R = 36.5g = 357.3N$ |$M1A1$

$\Rightarrow R_Q = 69.5g = 681.5$ |$A1$

(b) Resolve vertically $= 2R_R + R_R = 18 + 62 + 26 = 106g$ |$M1A1$

$\Rightarrow R_R = \frac{106}{3}g$

moments at Q $\Rightarrow 26g \times 0.3 + R_R \times 2.2 = 18g \times 1.1 + 62g \times QX$ |$M1A1$

$\Rightarrow QX = 1.06m$ |$M1A1$

A209 - ID: 6977 [12 marks, 14 minutes]

(a) Moments at Q $\Rightarrow 54g(1.8 - x) + 24g \times 0.8 = T_P \times 1.8$ |$M1A1$

$\Rightarrow 952.56 - 529.2x + 188.16 = T_P \times 1.8$

$\Rightarrow T_P = 633.733 - 294x$ |$A1$

(b) Resolve vertically $\Rightarrow T_P + T_Q = 78g$ |$M1A1$

$\Rightarrow T_Q = 130.667 + 294x$ |$A1$

(c) $0 < x < 1.6 \Rightarrow 163.333 < T_P < 633.733$ |$M1A1$

$\Rightarrow 130.667 < T_Q < 601.067$ |$A1$

(d) $T_Q = 3T_P \Rightarrow 130.667 + 294x = 3(633.733 - 294x)$ |$M1$

$\Rightarrow 130.667 + 294x = 1901.2 - 882x$

$\Rightarrow 1176x = 1770.533$

$\Rightarrow x = 1.506$ |$M1A1$

A210 - ID: 7272 [10 marks, 12 minutes]

(a) moments at A $\Rightarrow 2.7T_C = 2W + 4 \times 19$ |$M1A1$

$\Rightarrow T_C = \frac{2}{2.7}W + \frac{76}{2.7}$

$\Rightarrow T_C = \left(\frac{20}{27}W + \frac{760}{27}\right)N$ |$M1A1$

(b) $\updownarrow \Rightarrow T_A + T_C = W + 19$ |$M1A1$

$\Rightarrow T_A = W + 19 - \left(\frac{20}{27}W + \frac{760}{27}\right)N$

$\Rightarrow T_A = \left(\frac{7}{27}W - \frac{247}{27}\right)N$ |$A1$

(c) $T_C = 5T_A \Rightarrow \left(\frac{20}{27}W + \frac{760}{27}\right) = 5\left(\frac{7}{27}W - \frac{247}{27}\right)$ |$M1$

$\Rightarrow \frac{20}{27}W + \frac{760}{27} = \frac{35}{27}W - \frac{1235}{27}$

$\Rightarrow \frac{665}{9} = \frac{5}{9}W$

$\Rightarrow W = 133$ |$M1A1$

A211 - ID: 848 [7 marks, 8 minutes]

(a) (↕) $R + R = 120 + 50$ |$M1$

$\Rightarrow R = 85kg = 85 \times 9.8N$

$\Rightarrow R = 833N$ |$A1$

(b) Moments at A $\Rightarrow 50 \times 5 + 120 \times x = 85 \times 11$

$\Rightarrow 120x = 685$ |$M1A2$

$\Rightarrow x = 5.71m$ |$M1A1$

A212 - ID: 922 [8 marks, 10 minutes]

(a) moments at C $\Rightarrow 22g \times 2 = 40g \times x$ |$M1A1$

$\Rightarrow x = 1.1\,m$ |$A1$

(b) weight acts at midpoint |$B1$

(c) moments at C $\Rightarrow 20g \times y + 22g \times 2 = 40g \times 1.4$ |$M1A1$

$\Rightarrow y = 0.6\,m$ |$M1A1$

A213 - ID: 414 [12 marks, 14 minutes]

(a) Reaction $= 0$ |$B1$

(b) Moments at D : $3.5W = 1200 \times 9$ |$M1A1$

$\Rightarrow W = 3085.714N$ |$A1$

(c) Moments at D : $1200 \times 9 = W(7 - x)$ |$M1A1$

Moments at C : $800 \times 9 = Wx$ |$M1A1$

$\Rightarrow 1200 \times 9 = 7W - 800 \times 9$

$\Rightarrow W = \frac{1200 \times 9 + 800 \times 9}{7}$

$\Rightarrow W = 2571.429N$ |$M1A1$

(d) $x = \frac{800 \times 9}{2571.429}$ |$M1$

$= 2.8m$ |$A1$

A214 - ID: 703 [10 marks, 12 minutes]

(a) moments at C $\Rightarrow 100 \times x = 130 \times 1.35$ |$M1A1$

$\Rightarrow x = 1.755\,m$ |$A1$

(b) Reaction at $C = \Leftrightarrow 130 \times 0.405 = W \times 1.945$ |$B1M1A1$

$\Rightarrow W = 27.069\,N$ |$A1$

(c) Reaction at $D = 27.069 + 130 = 157.069N$ |$M1A1$

(d) How : the weight of the rock acts precisely at B. |$B1$

A215 - ID: 7395 [5 marks, 6 minutes]

Resolve $\updownarrow \Rightarrow R_p + R_q = 4 + 8 = 12N$ |$M1A1$
Assume : body placed to right of Q
greatest value $\Rightarrow$ rod about to tilt
$\Rightarrow R_p = 0$ |$M1$
$\Rightarrow R_q = 12$
moments at C $\Rightarrow 8 \times x = R_q \times 6$
$\Rightarrow 8x = 72$
$\Rightarrow x = 9\,cm$ |$M1A1$

A216 - ID: 7398 [8 marks, 10 minutes]

(a) Moments at P $\Rightarrow 1018 \times 3.6 = mg \times 1.8 + 82g \times 4.3$ |$M2A2$
$\Rightarrow 3664.8 = mg \times 1.8 + 352.6g$
$\Rightarrow 209.32 = 1.8mg$
$\Rightarrow m = 11.866\,kg$ |$A1$
(b) Starts to tilt $\Rightarrow R_p = 0$ |$M1$
$\Rightarrow R_q = 11.866g + 82g = 919.9\,N$ |$M1A1$

A217 - ID: 660 [13 marks, 16 minutes]

(a) At time t : $\underline{r}_A = (-8 + 4t)\,\underline{i} + (10 + 3t)\underline{j}$ |$B1$
: $\underline{r}_B = (2 + -4t)\,\underline{i} + (5 + 7t)\underline{j}$ |$B1$
$\underline{i}$ equal $\Rightarrow (-8 + 4t) = (2 + -4t)$ |$M1$
$\Rightarrow t = 1.25$ |$A1$
$\Rightarrow \underline{r}_A = -3\underline{i} + 13.75\underline{j},\quad \underline{r}_B = -3\underline{i} + 13.75\underline{j}$
$\Rightarrow$ Collide |$M1A1$
(b) New $\underline{r}_A = (-8 + 2t)\,\underline{i} + (10 + 2t)\underline{j}$
$\Rightarrow \vec{AB} = \underline{r}_B - \underline{r}_A = (10 + -6t)\,\underline{i} + (-5 + 5t)\underline{j}$ |$M1A1$
(c) $t = 2 \Rightarrow \vec{AB} = -2\underline{i} + 5\underline{j}$ |$M1$
$\Rightarrow |AB| = \sqrt{(-2)^2 + (5)^2} = 5.39km$ |$M1A1$
(d) B north of A $\Rightarrow (10 + -6t) = 0$
$\Rightarrow t = \frac{10}{6} = 1340hours$ |$M1A1$

A218 - ID: 421 *[15 marks, 18 minutes]*

(a) $\underset{\sim}{r} = 20t\underset{\sim}{i}$ |$B1$

$\underset{\sim}{s} = (200 + 10t)\ \underset{\sim}{i} + 6t\underset{\sim}{j}$ |$M1A1$

(b) $\vec{AB} = \underset{\sim}{s} - \underset{\sim}{r}$

$\Rightarrow \vec{AB} = (200 + 10t)\underset{\sim}{i} + 6t\underset{\sim}{j} - 20ti$

$\Rightarrow \vec{AB} = (200 + -10t)\underset{\sim}{i} + 6t\underset{\sim}{j}$ |$A1$

(c) bearing=45$\Rightarrow \frac{6t}{200+-10t} = 1$ |$M2A1$

$\Rightarrow 6t = 200 + -10t$ |$M1$

$\Rightarrow t = 12.5$ |$A1$

(d) dist = 200$\Rightarrow |\underset{\sim}{s} - \underset{\sim}{r}|^2 = 200^2$ |$M1$

$\Rightarrow (200 + -10t)^2 + (6t)^2 = 200^2$ |$M1A1$

$\Rightarrow 200^2 + -4000t + 100t^2 + 36t^2 = 200^2$ |$A1$

$\Rightarrow 136t^2 = 4000t$

$\Rightarrow t = 29.412$ |$M1A1$

A219 - ID: 949 *[5 marks, 6 minutes]*

$\updownarrow$ component $= 5.\sin 40 = 3.214$ |$B1$

$\leftrightarrow$ component $= 3 + 5.\cos 40 = 6.83$ |$B1$

$\Rightarrow$ magnitude $= \sqrt{(3.214)^2 + (6.83)^2}$ |$M1$

$\Rightarrow$ magnitude $= 7.55N$ |$A1$

angle $= \tan^{-1}\left(\frac{3.214}{6.83}\right)$

$= 25.199°$ |$A1$