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(1) Santa's sledge of mass 22kg is being dragged up a smooth slope angled at 30^o to the horizontal by a rope inclined at 60^o to the **slope**. The total resistances to motion on the sledge are 12N.
(a) Find the least value of tension in the rope such that the sledge accelerates at more than $1ms^{-2}$ up the slope.
The rope suddenly snaps. One of Santa's little helpers tries to stop the sledge from travelling back down the slope. Given the 12N force still resists motion:
(b) Find the minimum force the little helper must apply parallel to the slope to keep the sledge from moving down the slope.

(2) Two particles sit side by side on a wide, rough slope angled at 45^o to the horizontal. Particle A has mass 3kg and particle B has mass 5kg. Both particles are released from rest. Given particle A takes 3 seconds and particle B 4 seconds to travel 8 meters down the slope, find the value of $\mu_B - \mu_A$ where μ_A and μ_B are the coefficients of friction between particles A and B and the slope. Give your answer to 3 significant figures.

(3) A particle is projected up a rough 30 meter slope inclined at an angle β where $\tan\beta = 0.75$ with speed $20ms^{-1}$. Given the particle falls 6.8 meters short of reaching the top of the slope, find:
(a) The time taken for the particle to return to its starting position.
(b) The coefficient of friction between the particle and the slope.

(4) Two boxes are connected by a light inextensible string which passes over a smooth, fixed pulley at the top of a wedge. Box A has mass $2m$kg and box B $m$kg. Box A lies on the plane angled at 30^o to the horizontal and box B lies on the plane angled at 60^o to the horizontal. Both planes have rough surfaces where the coefficient of friction between the boxes and the planes are μ_A and μ_B respectively.
Given the tension in the string is 50N and box A accelerates down the plane at $1ms^{-2}$:
(a) Express μ_A in terms of m
(b) Express μ_B in terms of m
Given further the coefficient of friction between the boxes and their respective planes are equal:
(c) Find the mass of each box.

(5) A car of mass 800kg is towing a caravan of mass 300kg by means of a rigid tow bar up a hill with speed $20ms^{-1}$ and acceleration $2ms^{-2}$. A force of 200N is retarding the progress of the car and a force of 100N is retarding the progress of the caravan. Given the hill is inclined at an angle of 10^o to the horizontal:
(a) Find the magnitude of the driving force of the cars engine.
(b) The magnitude of the force in the rigid tow bar.
After 3 seconds the tow bar snaps. The car continues to move up the hill with the driving force found in part (a) and still has 200N retarding it's progress. Find how far the car is ahead of the caravan when the caravan comes to rest.

(6) Two particles P and Q of mass 4kg and 3kg respectively are connected by light inextensible string. Both particles hang 2 meters above the ground at rest over a smooth fixed pulley.
The particles are released from rest.
(a) Find the acceleration of particle P and hence state the acceleration of Q.
(b) Find the tension in the string.
(c) State the modelling assumptions that you have made.
(d) Sketch an acceleration/time graph for particle Q from the moment of release to the time when it reaches its maximum height. The values given on your graph axis must be correct to 3 significant figures where appropriate. (You may assume particle Q doesn't hit the pulley)

(7) A particle of mass 5kg is at rest on a rough plane inclined at an angle α to the horizontal where $\sin\alpha = 0.8$. The particle is connected to second particle of mass 2kg by a light inextensible string over a smooth pulley fixed at the top of the plane. The 2kg particle hangs freely one meter below the pulley.
Given the particle of mass 5kg accelerates down the plane with acceleration $0.5ms^{-2}$:
(a) Find the tension in the string.
(b) Find the coefficient of friction between the 5kg particle and the plane.
(c) Find the magnitude of the force exerted on the pulley.
(d) Write down the distance travelled by the 5kg particle when the 2kg particle hits the pulley.
(e) Draw a velocity/time graph for the motion of the 5kg particle from the time it's released from rest until the time the 2kg particle hits the pulley.