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MATHEMATICS M1

Mechanics 1

A.M. TUESDAY, 16 January 2007

($1\frac{1}{2}$ hours)

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a 12 page answer book;
- a Formula Booklet;
- a calculator.

INSTRUCTIONS TO CANDIDATES

Answer **all** questions.

Take g as 9·8 ms $^{-2}$.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

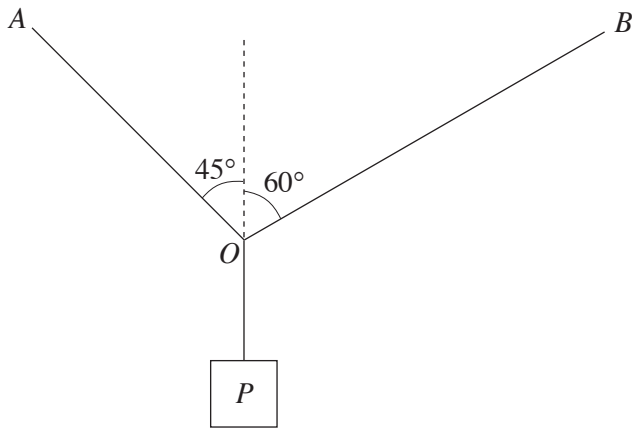
You are reminded of the necessity for good English and orderly presentation in your answers.

1. A pebble is projected vertically upwards with speed 10·5 ms^{-1} from a point *A* at the top of a cliff.

(a) Find the greatest height above *A* reached by the pebble. [3]

(b) The pebble reached the bottom of the cliff 5 s after being projected. Calculate the height of the cliff. [3]

2. The diagram shows a body *P*, of mass 30 kg, suspended in equilibrium by means of light inextensible strings *OA*, *OB* and *OP*. The strings *OA* and *OB* are inclined at 45° and 60° to the vertical respectively.



(a) Find, in Newtons, the tension in the string *OP*. [1]

(b) Draw a diagram showing the forces acting at the point *O*. [1]

(c) Calculate the forces in the strings *OA* and *OB*. [8]

3. The mass of a lift is 5600 kg. The lift starts from rest and descends with uniform acceleration for 8 s until it reaches a speed of *V* ms^{-1}. The tension in the lift cable is 50 400 N.

(a) Show that the magnitude of the acceleration of the lift is 0·8 ms^{-2}. [2]

(b) Find the value of *V*. [2]

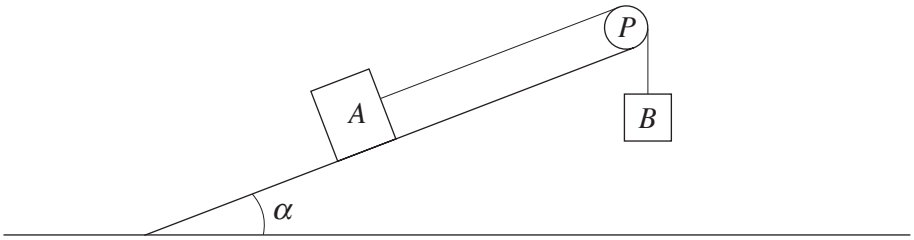
The lift maintains this constant speed of *V* ms^{-1} for 25 s before decelerating uniformly to rest. The **total** time for descent is 40 s.

(c) Draw a sketch of the velocity-time graph of the motion. [3]

(d) Calculate the total distance that the lift descends. [3]

(e) Find the maximum tension in the lift cable during the motion. [3]

4. The diagram shows a particle *A*, on a fixed smooth inclined plane, joined by a light inextensible string passing over a smooth fixed pulley *P* to a particle *B*, which hangs freely. The plane is inclined at an angle α to the horizontal, where $\sin \alpha = 0{\cdot}21$. The masses of *A* and *B* are 5 kg and 9 kg respectively. The string is in the same vertical plane as a line of greatest slope of the plane. Initially, the particles are held at rest with the string taut.



The system is released. Calculate the magnitude of the acceleration of the particle *A* and the tension in the string. [7]

5. A body, of mass 80 kg, slides in a straight line with constant deceleration across the horizontal surface of an ice rink. Its initial speed is 9 ms^{-1} and the body travels 75 m before coming to rest.

(a) Calculate the magnitude of the deceleration of the body. [3]

(b) Find the time that elapses before the body comes to rest. [3]

(c) Assuming that the frictional force is the only force acting on the body that has a horizontal component, calculate the coefficient of friction between the body and the surface of the ice rink, giving your answer correct to two significant figures. [5]

6. A sphere *A*, of mass 2 kg, collides directly with another sphere *B*, of mass 5 kg, on a smooth horizontal surface. Before the collision *A* moves with speed 6 ms^{-1} and after the collision, it moves with speed 4 ms^{-1} in the opposite direction. The coefficient of restitution between the spheres is $\frac{3}{4}$.

(a) Find the magnitude of the impulse exerted by *B* on *A* during the collision. [2]

(b) Calculate the speeds of *B* before and after the collision. [7]

TURN OVER.

7. The diagram shows a uniform plank *XY,* of mass 40 kg and length 3 m, resting on two supports at *P* and *Q,* where $XP = 0{\cdot}7$ m, and $QY = 0{\cdot}9$ m.

A boy *A,* of mass 45 kg, sits on the plank at the point *P* and a boy *B*, of mass 70 kg, sits on the plank at the end *Y.*

(a) Modelling the boys as particles, calculate the magnitudes of the normal reactions of the supports on the plank. [6]

(b) State what would happen if *A* jumps off the plank. Give a reason for your answer. [2]

8. A uniform square lamina *ABCD* has sides 9 cm. The point *E* lies on *AD* and is such that $ED = 6$ cm. The triangle *EDC* is removed.

(a) Find the distance of the centre of mass of the remaining lamina *ABCE* from

(i) *AB,*

(ii) *AE.* [8]

(b) The lamina *ABCE* is freely suspended from *C* and hangs in equilibrium. Calculate the angle *BC* makes with the vertical. [3]