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MATHEMATICS M1

Mechanics 1

P.M. TUESDAY, 6 June 2006

($1\frac{1}{2}$ 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 $9{\cdot}8$ 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 lift, starting from rest, descends with a uniform acceleration of 3 ms^{-2} until it reaches a speed of 9 ms^{-1}. It then travels at a constant speed of 9 ms^{-1} for a short time and finally, it is brought to rest with a uniform retardation of 2 ms^{-2}. An object, of mass 6 kg, is on the floor of the lift. Calculate the magnitude of the reaction of the floor on the object during each of the three stages of the motion. [5]

2. A train, starting from rest from station *A,* travels along a straight horizontal track until it stops at station *B,* which is 2400 m from *A*. Initially, the train accelerates at a uniform rate of 0·4 ms^{-2} until it reaches a speed of 16 ms^{-1}. It then maintains this speed of 16 ms^{-1} for *T* s, before decelerating uniformly to rest in 20 s.

(a) Calculate the time taken for accelerating. [2]

(b) Draw a sketch of the *v-t* graph for the journey from *A* to *B*. [4]

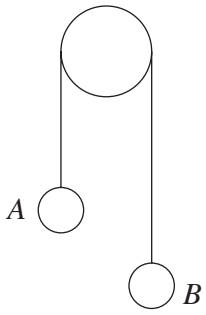
(c) Find the value of *T*. [4]

3. A box of mass 20 kg is at rest on a rough horizontal floor. The coefficient of friction between the box and the floor is 0·3. The box is subjected to a horizontal force of *T*N.

(a) Given that $T = 65$, find the magnitude of the acceleration of the box. [5]

(b) Given that $T = 45$, find the magnitude of the frictional force. [1]

4. The diagram shows two particles *A* and *B,* of mass 3·1 kg and 1·8 kg respectively, connected by a light inextensible string passing over a fixed smooth pulley. Initially, *B* is held at rest with the string taut. It is then released.



Calculate the magnitude of the acceleration of *A* and the tension in the string. [6]

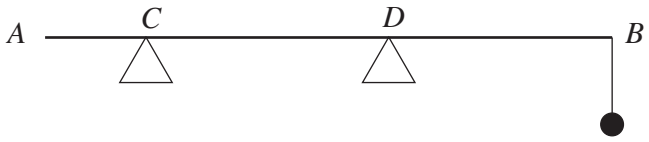
5. A particle is projected vertically upwards with speed 22·05 ms^{-1}.

(a) Calculate the time that elapses before the particle returns to the point of projection and the speed of the particle at that time. [4]

(b) Find the greatest height of the particle above the point of projection. [3]

(c) Determine the speed and direction of motion of the particle 3 s after projection. [4]

6. The diagram shows a uniform straight rod AB, of length 3·8 m, resting horizontally in equilibrium on two smooth supports at C and D with an object of mass 2·2 kg freely suspended from point B.



The mass of the rod is 4·4 kg, AC = 0·4 m and AD = 2·6 m. Calculate the magnitudes of the reactions at C and D. [7]

7. A particle A, of mass 0·1 kg, moving with speed 10 ms^{-1} on a smooth horizontal plane collides directly with another particle B, of mass 0·6 kg moving with speed 2 ms^{-1} in the same direction.

The coefficient of restitution between the two particles is $\frac{3}{4}$.

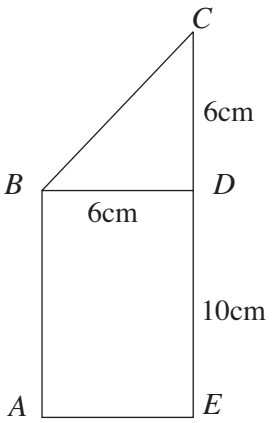
(a) Find the speeds of A and B after the collision. [7]

After the collision between A and B, particle B strikes a smooth vertical wall at right-angles to its direction of motion. The coefficient of restitution between B and the wall is $\frac{1}{4}$.

(b) Show that A and B do not collide again. [2]

(c) Calculate the magnitude of the impulse of the wall on B. [2]

8. The diagram shows a uniform plane lamina $ABCDE$, in which $ABDE$ is a rectangle and BCD is a right-angled isosceles triangle with $DB = DC$. The lengths BD and DE are 6 cm and 10 cm respectively.



(a) Find the distance of the centre of mass of the lamina $ABCDE$ from

(i) AB,
(ii) AE. [9]

(b) The lamina $ABCDE$ is freely suspended from the point X on AE such that it hangs in equilibrium with AB vertical. Write down the distance AX. [1]

9. A body of mass 15 kg is on a rough plane inclined at an angle of 25° to the horizontal. The coefficient of friction between the body and the plane is 0·4. The body is held at rest by means of a light string, which is parallel to a line of greatest slope of the plane. The magnitude of the tension in the string is T N. Find the greatest and the least possible values of T, giving your answers correct to two decimal places. [9]