Mechanics M1 Advanced Subsidiary

For Edexcel

Paper A

Time: 1 hour 30 minutes

Total marks 75

Instructions and Information

Candidates may use any calculator EXCEPT those with the facility for symbolic algebra, differentiation and/or integration.

Full marks may be obtained for answers to ALL questions.

The booklet 'Mathematical Formulae and Statistical Tables', available from Edexcel, may be used.

Whenever a numerical value of g is required, take $g = 9.8\,\text{ms}^{-2}$.

When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Advice to Candidates

You must show sufficient working to make your methods clear to an examiner.
Answers without working may gain no credit.

Published by Elmwood Press
80 Attimore Road
Welwyn Garden City
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1. An unloaded railway truck of mass 2000 kg is moving along a straight horizontal track with speed $5\,\text{ms}^{-1}$. It collides with a loaded truck of mass 3000 kg which is stationary. When the trucks collide they couple and move on together. Find

(a) the speed of the trucks immediately after the collision. **(3)**

(b) the impulse exerted on the stationary truck in the collision. **(2)**

A short distance after the collision the trucks run into some buffers which provide a constant horizontal resistive force of magnitude R newtons. This force brings the trucks to rest in a time of 1.6 seconds.

(c) Find R. **(3)**

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2. A footbridge across a stream consists of a uniform plank of length 6 m and mass 40 kg. The footbridge is supported at its ends A and B. A man of mass 80 kg stands on the footbridge at point C. The magnitude of the force exerted by the support at B is twice the magnitude of the force exerted by the support at A. By modelling the footbridge as a uniform rod and the man as a particle, find

(a) the magnitude of the force exerted by the support at A, **(2)**

(b) the distance AC. **(4)**

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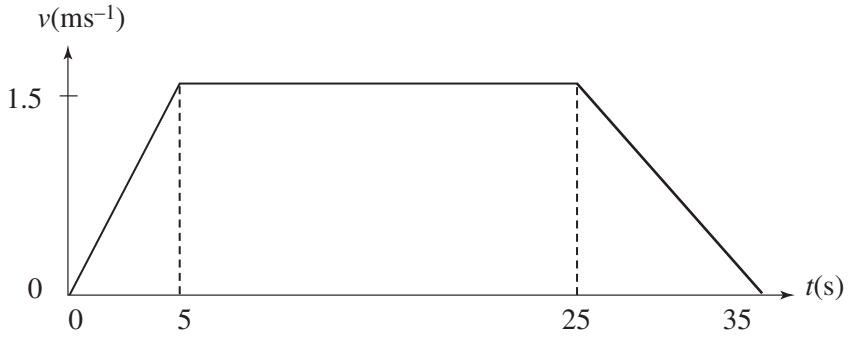
3. A child in a pedal-car moves along a straight horizontal path. This motion is shown in the velocity – time graph.



(a) Calculate the total distance travelled by the child. **(3)**

(b) Calculate the deceleration of the child during the last 10 seconds of the motion. **(2)**

During the last 10 seconds of the motion the child steps pedalling and a constant horizontal resistance force acts on the pedal-car. If the combined mass of the child and pedal-car is 30 kg, find

(c) The magnitude of this resistive force. **(2)**

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4. A car of mass 1000 kg tows a caravan of mass 500 kg by means of a light horizontal tow bar. The car and caravan are moving along a straight, level road. The resistances to motion of the car and caravan are 550 N and 250 N respectively. The engine exerts a driving force of 2000 N. Find

(*a*) the acceleration of the car and caravan, **(6)**

(*b*) the tension in the tow bar. **(3)**

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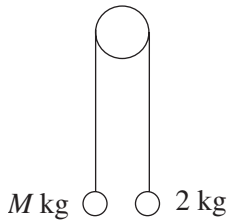
5. Two small balls of mass 2 kg and M kg are connected by a cord which passes over a smooth pulley as shown in the diagram.



The particles are released from rest with the string taut. The 2 kg ball moves vertically downwards and travels 0.5 m in 1.4 seconds. Find

(*a*) the acceleration of the system, **(3)**

(*b*) the tension in the string, **(3)**

(*c*) the value of M. **(4)**

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6. A rope is used to pull a block of mass 10 kg up a rough plane inclined at 25° to the horizontal. The rope is parallel to a line of greatest slope of the plane and the tension in the rope is 60 N. The block moves at constant speed. Find

(*a*) the normal reaction of the plane on the box, **(3)**

(*b*) the coefficient of friction between the block and the plane. **(5)**

(*c*) State two modelling assumptions you have used in your calculation. **(2)**

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7. Two constant forces $(4\mathbf{i} + 5\mathbf{j})$ N and $(2\mathbf{i} - 8\mathbf{j})$ N act on a particle P, of mass 3 kg. Find

(a) the resultant force acting on P in vector form **(1)**

(b) the acceleration of P in vector form **(2)**

(c) the angle between the acceleration vector and the unit vector $\mathbf{j}$. **(3)**

If the initial velocity of P is $(3\mathbf{i} - 2\mathbf{j})\,\text{ms}^{-1}$, find

(d) the speed of P after 3 seconds. **(5)**

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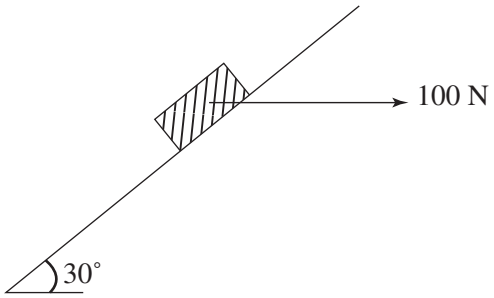
8. A box of mass 8 kg lies on a rough plane inclined at an angle of 30° to the horizontal. The box is held in equilibrium by a horizontal force of 100 newtons. The line of action of the force is in the same vertical plane as a line of greatest slope of the plane. The box, which is modelled as a particle, is in limiting equilibrium and about to move up the plane.



(a) Draw a diagram showing all the forces acting on the box. **(2)**

(b) Find the normal reaction between the box and the plane. **(3)**

(c) Find the coefficient of friction between the box and the plane. **(5)**

The horizontal force is removed.

(d) Find the acceleration of the box down the plane. **(4)**

END **TOTAL 75 MARKS**