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International Examinations Papers
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Mechanics

TOPIC- Kinematics

Basic

Kinematics-

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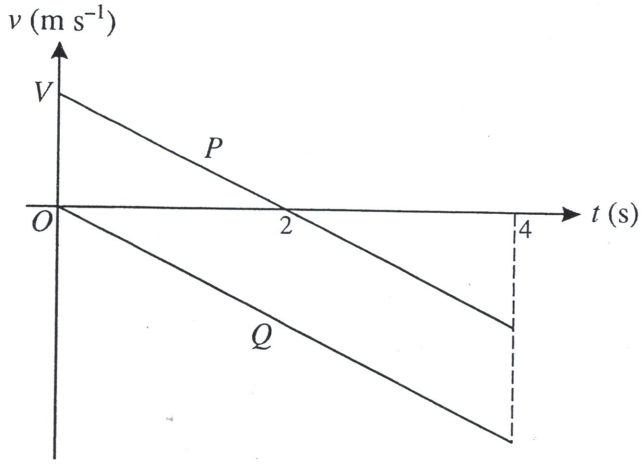

Two particles P and Q move vertically under gravity. The graphs show the upward velocity v m s^{-1} of the particles at time t s, for $0 \leqslant t \leqslant 4$. P starts with velocity V m s^{-1} and Q starts from rest.

(i) Find the value of V. [2]

Given that Q reaches the horizontal ground when $t = 4$, find

(ii) the speed with which Q reaches the ground, [1]

(iii) the height of Q above the ground when $t = 0$. [2]

2 A stone is released from rest and falls freely under gravity. Find

(i) the speed of the stone after 2 s, [1]

(ii) the time taken for the stone to fall a distance of 45 m from its initial position, [2]

(iii) the distance fallen by the stone from the instant when its speed is $30\ \text{m s}^{-1}$ to the instant when its speed is $40\ \text{m s}^{-1}$. [2]

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03 Two particles P and Q move on a line of greatest slope of a smooth inclined plane. The particles start at the same instant and from the same point, each with speed $1.3\,\text{m s}^{-1}$. Initially P moves down the plane and Q moves up the plane. The distance between the particles t seconds after they start to move is d m.

(i) Show that $d = 2.6t$. [4]

When $t = 2.5$ the difference in the vertical height of the particles is 1.6 m. Find

(ii) the acceleration of the particles down the plane, [3]

(iii) the distance travelled by P when Q is at its highest point. [3]

04 A particle P_1 is projected vertically upwards, from horizontal ground, with a speed of $30\,\text{m s}^{-1}$. At the same instant another particle P_2 is projected vertically upwards from the top of a tower of height 25 m, with a speed of $10\,\text{m s}^{-1}$. Find

(i) the time for which P_1 is higher than the top of the tower, [3]

(ii) the velocities of the particles at the instant when the particles are at the same height, [5]

(iii) the time for which P_1 is higher than P_2 and is moving upwards. [3]

05

A particle P of mass 0.6 kg is projected vertically upwards with speed 5.2 m s^{-1} from a point O which is 6.2 m above the ground. Air resistance acts on P so that its deceleration is 10.4 m s^{-2} when P is moving upwards, and its acceleration is 9.6 m s^{-2} when P is moving downwards. Find

(i) the greatest height above the ground reached by P, [3]

(ii) the speed with which P reaches the ground, [2]

(iii) the total work done on P by the air resistance. [4]

06 A particle starts from rest at the point A and travels in a straight line until it reaches the point B. The velocity of the particle t seconds after leaving A is $v\,\text{m s}^{-1}$, where $v = 0.009t^2 - 0.0001t^3$. Given that the velocity of the particle when it reaches B is zero, find

(i) the time taken for the particle to travel from A to B, [2]

(ii) the distance AB, [4]

(iii) the maximum velocity of the particle. [4]

7 A car of mass 1200 kg moves in a straight line along horizontal ground. The resistance to motion of the car is constant and has magnitude 960 N. The car's engine works at a rate of 17 280 W.

(i) Calculate the acceleration of the car at an instant when its speed is $12\,\text{m s}^{-1}$. [3]

The car passes through the points A and B. While the car is moving between A and B it has constant speed $V\,\text{m s}^{-1}$.

(ii) Show that $V = 18$. [2]

At the instant that the car reaches B the engine is switched off and subsequently provides no energy. The car continues along the straight line until it comes to rest at the point C. The time taken for the car to travel from A to C is 52.5 s.

(iii) Find the distance AC. [5]

0 8 A particle of mass 30 kg is on a plane inclined at an angle of 20° to the horizontal. Starting from rest, the particle is pulled up the plane by a force of magnitude 200 N acting parallel to a line of greatest slope.

(i) Given that the plane is smooth, find

(a) the acceleration of the particle, [2]

(b) the change in kinetic energy after the particle has moved 12 m up the plane. [2]

(ii) It is given instead that the plane is rough and the coefficient of friction between the particle and the plane is 0.12.

(a) Find the acceleration of the particle. [4]

(b) The direction of the force of magnitude 200 N is changed, and the force now acts at an angle of 10° above the line of greatest slope. Find the acceleration of the particle. [4]

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0 9 One end of a light inextensible string is attached to a block. The string makes an angle of 60° above the horizontal and is used to pull the block in a straight line on a horizontal floor with acceleration $0.5\,\text{m s}^{-2}$. The tension in the string is 8 N. The block starts to move with speed $0.3\,\text{m s}^{-1}$. For the first 5 s of the block's motion, find

(i) the distance travelled, [2]

(ii) the work done by the tension in the string. [2]

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10 An object is released from rest at a height of 125 m above horizontal ground and falls freely under gravity, hitting a moving target P. The target P is moving on the ground in a straight line, with constant acceleration $0.8\,\text{m s}^{-2}$. At the instant the object is released P passes through a point O with speed $5\,\text{m s}^{-1}$. Find the distance from O to the point where P is hit by the object. [4]

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11 A particle P is projected vertically upwards with speed $11\ \text{m s}^{-1}$ from a point on horizo
At the same instant a particle Q is released from rest at a point h m above the ground. P an
ground at the same instant, when Q has speed $V\ \text{m s}^{-1}$.

(i) Find the time after projection at which P hits the ground. [2

(ii) Hence find the values of h and V. [2]

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12 A and B are two points which are 10 m apart on the same horizontal plane. A particle P starts to move from rest at A, directly towards B, with constant acceleration 0.5 m s^{-2}. Another particle Q is moving directly towards A with constant speed 0.75 m s^{-1}, and passes through B at the instant that P starts to move. At time T s after this instant, particles P and Q collide. Find

(i) the value of T, [4]

(ii) the speed of P immediately before the collision. [1]

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3 The resistance to motion acting on a runner of mass 70 kg is κv N, where v m s^{-1} is the runner's speed and κ is a constant. The greatest power the runner can exert is 100 W. The runner's greatest steady speed on horizontal ground is 4 m s^{-1}.

(i) Show that $\kappa = 6.25$. [2]

(ii) Find the greatest steady speed of the runner while running uphill on a straight path inclined at an angle α to the horizontal, where $\sin \alpha = 0.05$. [4]

14 Particles P and Q move on a straight line AOB. The particles leave O simultaneously, with P moving towards A and with Q moving towards B. The initial speed of P is $1.3\ \text{m s}^{-1}$ and its acceleration in the direction OA is $0.1\ \text{m s}^{-2}$. Q moves with acceleration in the direction OB of $0.016t\ \text{m s}^{-2}$, where t seconds is the time elapsed since the instant that P and Q started to move from O. When $t = 20$, particle P passes through A and particle Q passes through B.

(i) Given that the speed of Q at B is the same as the speed of P at A, find the speed of Q at time $t = 0$. [4]

(ii) Find the distance AB. [3]

1 5 Particle P travels along a straight line from A to B with constant acceleration $0.05\,\text{m s}^{-2}$. Its speed at A is $2\,\text{m s}^{-1}$ and its speed at B is $5\,\text{m s}^{-1}$.

(i) Find the time taken for P to travel from A to B, and find also the distance AB. [3]

Particle Q also travels along the same straight line from A to B, starting from rest at A. At time t s after leaving A, the speed of Q is $kt^3\,\text{m s}^{-1}$, where k is a constant. Q takes the same time to travel from A to B as P does.

(ii) Find the value of k and find Q's speed at B. [5]

16 A particle P of mass 0.2 kg is released from rest at a point 7.2 m above the surface of the liquid in a container. P falls through the air and into the liquid. There is no air resistance and there is no instantaneous change of speed as P enters the liquid. When P is at a distance of 0.8 m below the surface of the liquid, P's speed is 6 m s^{-1}. The only force on P due to the liquid is a constant resistance to motion of magnitude R N.

(i) Find the deceleration of P while it is falling through the liquid, and hence find the value of R. [5]

The depth of the liquid in the container is 3.6 m. P is taken from the container and attached to one end of a light inextensible string. P is placed at the bottom of the container and then pulled vertically upwards with constant acceleration. The resistance to motion of R N continues to act. The particle reaches the surface 4 s after leaving the bottom of the container.

(ii) Find the tension in the string. [4]

17

The frictional force acting on a small block of mass 0.15 kg, while it is moving on a horizontal surface, has magnitude 0.12 N. The block is set in motion from a point X on the surface, with speed 3 m s^{-1}. It hits a vertical wall at a point Y on the surface 2 s later. The block rebounds from the wall and moves directly towards X before coming to rest at the point Z (see diagram). At the instant that the block hits the wall it loses 0.072 J of its kinetic energy. The velocity of the block, in the direction from X to Y, is v m s^{-1} at time t s after it leaves X.

(i) Find the values of v when the block arrives at Y and when it leaves Y, and find also the value of t when the block comes to rest at Z. Sketch the velocity-time graph. [9]

(ii) The displacement of the block from X, in the direction from X to Y, is s m at time t s. Sketch the displacement-time graph. Show on your graph the values of s and t when the block is at Y and when it comes to rest at Z. [4]

18 A particle is released from rest at a point H m above horizontal ground and falls vertically. The particle passes through a point 35 m above the ground with a speed of $(V - 10)\,\text{m s}^{-1}$ and reaches the ground with a speed of $V\,\text{m s}^{-1}$. Find

(i) the value of V, [3]

(ii) the value of H. [2]

19 The top of a cliff is 40 metres above the level of the sea. A man in a boat, close to the bottom of the cliff, is in difficulty and fires a distress signal vertically upwards from sea level. Find

(i) the speed of projection of the signal given that it reaches a height of 5 m above the top of the cliff, [2]

(ii) the length of time for which the signal is above the level of the top of the cliff. [2]

The man fires another distress signal vertically upwards from sea level. This signal is above the level of the top of the cliff for $\sqrt{(17)}$ s.

(iii) Find the speed of projection of the second signal. [3]

2 A particle of mass 0.5 kg starts from rest and slides down a line of greatest slope of a smooth plane. The plane is inclined at an angle of 30° to the horizontal.

(i) Find the time taken for the particle to reach a speed of 2.5 m s^{-1}. [3]

When the particle has travelled 3 m down the slope from its starting point, it reaches rough horizontal ground at the bottom of the slope. The frictional force acting on the particle is 1 N.

(ii) Find the distance that the particle travels along the ground before it comes to rest. [3]

2 1 A particle P is projected vertically upwards from a point O. When the particle is at a height of 0.5 m, its speed is $6\,\text{m s}^{-1}$. Find

(i) the greatest height reached by the particle above O, [3]

(ii) the time after projection at which the particle returns to O. [3]

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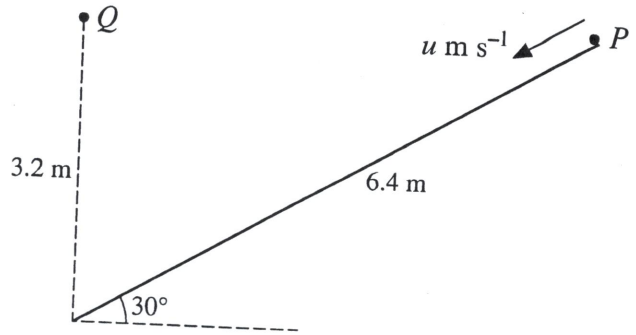

A particle P is projected from the top of a smooth ramp with speed u m s^{-1}, and travels down a line of greatest slope. The ramp has length 6.4 m and is inclined at 30° to the horizontal. Another particle Q is released from rest at a point 3.2 m vertically above the bottom of the ramp, at the same instant that P is projected (see diagram). Given that P and Q reach the bottom of the ramp simultaneously, find

(i) the value of u, [4]

(ii) the speed with which P reaches the bottom of the ramp. [2]

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2 3 A car travels along a straight road with constant acceleration $a\,\text{m s}^{-2}$. It passes through points A, B and C; the time taken from A to B and from B to C is 5 s in each case. The speed of the car at A is $u\,\text{m s}^{-1}$ and the distances AB and BC are 55 m and 65 m respectively. Find the values of a and u. [6]

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24 Particles P and Q are moving in a straight line on a rough horizontal plane. The frictional forces are the only horizontal forces acting on the particles.

(i) Find the deceleration of each of the particles given that the coefficient of friction between P and the plane is 0.2, and between Q and the plane is 0.25. [2]

At a certain instant, P passes through the point A and Q passes through the point B. The distance AB is 5 m. The velocities of P and Q at A and B are 8 m s^{-1} and 3 m s^{-1}, respectively, both in the direction AB.

(ii) Find the speeds of P and Q immediately before they collide. [5]

25 A particle P is projected vertically upwards from a point on the ground with speed $17\,\text{m s}^{-1}$. Another particle Q is projected vertically upwards from the same point with speed $7\,\text{m s}^{-1}$. Particle Q is projected T seconds later than particle P.

(i) Given that the particles reach the ground at the same instant, find the value of T. [2]

(ii) At a certain instant when both P and Q are in motion, P is 5 m higher than Q. Find the magnitude and direction of the velocity of each of the particles at this instant. [6]

26 A ball A is released from rest at the top of a tall tower. One second later, another ball B is projected vertically upwards from ground level near the bottom of the tower with a speed of $20\,\text{m s}^{-1}$. The two balls are at the same height 1.5 s after ball B is projected.

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(i) Show that the height of the tower is 50 m. [3]

(ii) Find the length of time for which ball B has been in motion when ball A reaches the ground. Hence find the total distance travelled by ball B up to the instant when ball A reaches the ground. [5]

27 A particle P moves in a straight line $ABCD$ with constant deceleration. The velocities of P at A, B and C are $20\,\text{m s}^{-1}$, $12\,\text{m s}^{-1}$ and $6\,\text{m s}^{-1}$ respectively.

(i) Find the ratio of distances $AB : BC$. [4]

(ii) The particle comes to rest at D. Given that the distance AD is 80 m, find the distance BC. [3]