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Mechanics

TOPIC- Energy, Work & Power

Kinetic energy

01 A car of mass 1000 kg moves along a horizontal straight road, passing through points *A* and *B*. The power of its engine is constant and equal to 15 000 W. The driving force exerted by the engine is 750 N at *A* and 500 N at *B*. Find the speed of the car at *A* and at *B*, and hence find the increase in the car's kinetic energy as it moves from *A* to *B*.

4r–N–9 [4]

Energy, Work & Power-KE

A crate of mass 50 kg is dragged along a horizontal floor by a constant force of magnitude 400 N acting at an angle $\alpha°$ upwards from the horizontal. The total resistance to motion of the crate has constant magnitude 250 N. The crate starts from rest at the point O and passes the point P with a speed of $2\ \mathrm{m\,s^{-1}}$. The distance OP is 20 m. For the crate's motion from O to P, find

(i) the increase in kinetic energy of the crate, [1]

(ii) the work done against the resistance to the motion of the crate, [1]

(iii) the value of α. [3]

3 A plane is inclined at an angle of $\sin^{-1}(\frac{1}{8})$ to the horizontal. A and B are two points on the same line of greatest slope with A higher than B. The distance AB is 12 m. A small object P of mass 8 kg is released from rest at A and slides down the plane, passing through B with speed 4.5 m s^{-1}. For the motion of P from A to B, find

42-J-15

(i) the increase in kinetic energy of P and the decrease in potential energy of P, [3]

(ii) the magnitude of the constant resisting force that opposes the motion of P. [2]

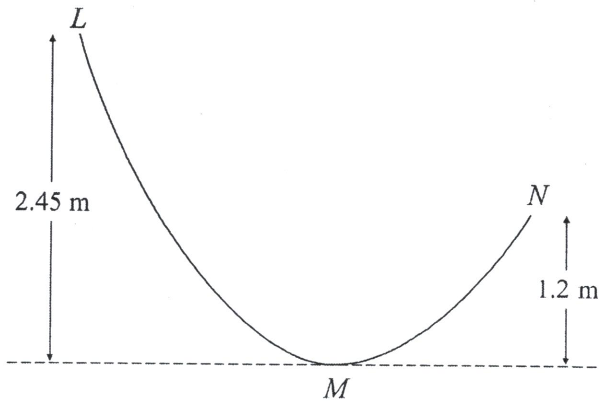
04 A lorry of mass 14 000 kg moves along a road starting from rest at a point O. It reaches a point A, and then continues to a point B which it reaches with a speed of $24\,\text{m s}^{-1}$. The part OA of the road is straight and horizontal and has length 400 m. The part AB of the road is straight and is inclined downwards at an angle of $\theta°$ to the horizontal and has length 300 m. J–15–41–4

(i) For the motion from O to B, find the gain in kinetic energy of the lorry and express its loss in potential energy in terms of θ. [3]

The resistance to the motion of the lorry is 4800 N and the work done by the driving force of the lorry from O to B is 5000 kJ.

(ii) Find the value of θ. [3]

05



The diagram shows the vertical cross-section LMN of a fixed smooth surface. M is the lowest point of the cross-section. L is 2.45 m above the level of M, and N is 1.2 m above the level of M. A particle of mass 0.5 kg is released from rest at L and moves on the surface until it leaves it at N. Find

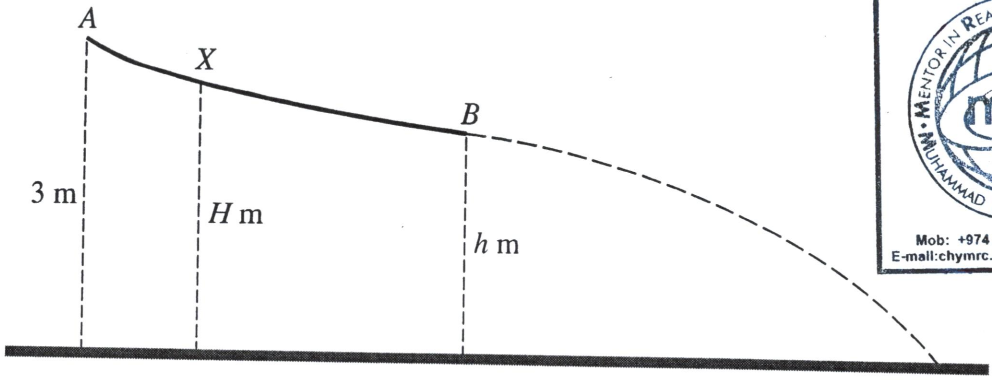
(i) the greatest speed of the particle, [3]

(ii) the kinetic energy of the particle at N. [2]

The particle is now projected from N, with speed $v\,\text{m}\,\text{s}^{-1}$, along the surface towards M.

(iii) Find the least value of v for which the particle will reach L. [2]

06



41-N-10

A smooth slide AB is fixed so that its highest point A is 3 m above horizontal ground. B is h m above the ground. A particle P of mass 0.2 kg is released from rest at a point on the slide. The particle moves down the slide and, after passing B, continues moving until it hits the ground (see diagram). The speed of P at B is v_B and the speed at which P hits the ground is v_G.

(i) In the case that P is released at A, it is given that the kinetic energy of P at B is 1.6 J. Find

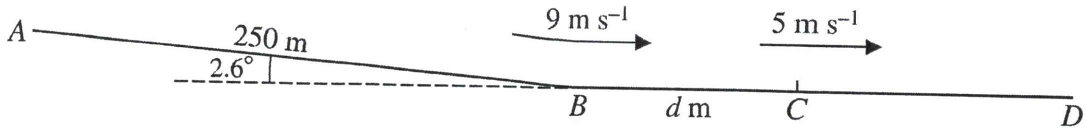
(a) the value of h, [3]

(b) the kinetic energy of the particle immediately before it reaches the ground, [1]

(c) the ratio $v_G : v_B$. [2]

(ii) In the case that P is released at the point X of the slide, which is H m above the ground (see diagram), it is given that $v_G : v_B = 2.55$. Find the value of H correct to 2 significant figures. [3]

07



A cyclist and his machine have a total mass of 80 kg. The cyclist starts from rest at the top A of a straight path AB, and freewheels (moves without pedalling or braking) down the path to B. The path AB is inclined at 2.6° to the horizontal and is of length 250 m (see diagram).

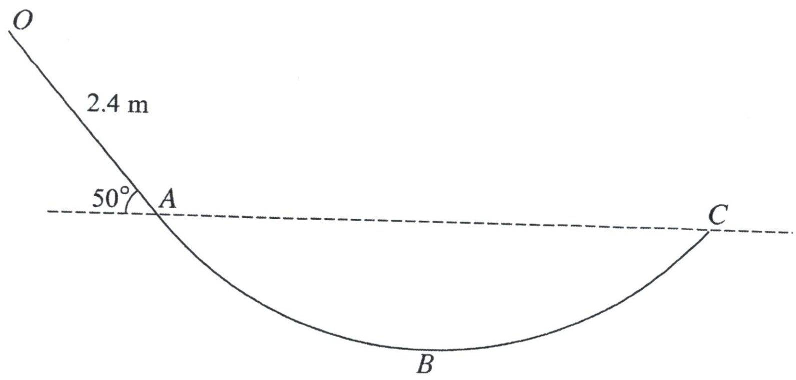
(i) Given that the cyclist passes through B with speed $9\,\text{m}\,\text{s}^{-1}$, find the gain in kinetic energy and the loss in potential energy of the cyclist and his machine. Hence find the work done against the resistance to motion of the cyclist and his machine. [3]

The cyclist continues to freewheel along a horizontal straight path BD until he reaches the point C, where the distance BC is d m. His speed at C is $5\,\text{m}\,\text{s}^{-1}$. The resistance to motion is constant, and is the same on BD as on AB.

(ii) Find the value of d. [3]

The cyclist starts to pedal at C, generating 425 W of power.

(iii) Find the acceleration of the cyclist immediately after passing through C. [3]



OABC is a vertical cross-section of a smooth surface. The straight part *OA* has length 2.4 m and makes an angle of 50° with the horizontal. *A* and *C* are at the same horizontal level and *B* is the lowest point of the cross-section (see diagram). A particle *P* of mass 0.8 kg is released from rest at *O* and moves on the surface. *P* remains in contact with the surface until it leaves the surface at *C*. Find

(i) the kinetic energy of *P* at *A*, [2]

(ii) the speed of *P* at *C*. [2]

The greatest speed of *P* is $8\ \mathrm{m\,s^{-1}}$.

(iii) Find the depth of *B* below the horizontal through *A* and *C*. [3]

09 A block of mass 20 kg is pulled from the bottom to the top of a slope. The slope has length 10 m and is inclined at 4.5° to the horizontal. The speed of the block is $2.5\,\mathrm{m\,s^{-1}}$ at the bottom of the slope and $1.5\,\mathrm{m\,s^{-1}}$ at the top of the slope.

42–N–10

(i) Find the loss of kinetic energy and the gain in potential energy of the block. [3]

(ii) Given that the work done against the resistance to motion is 50 J, find the work done by the pulling force acting on the block. [2]

(iii) Given also that the pulling force is constant and acts at an angle of 15° upwards from the slope, find its magnitude. [2]

10 A car of mass 1250 kg moves from the bottom to the top of a straight hill of length 500 m. The top of the hill is 30 m above the level of the bottom. The power of the car's engine is constant and equal to 30 000 W. The car's acceleration is $4\,\text{m}\,\text{s}^{-2}$ at the bottom of the hill and is $0.2\,\text{m}\,\text{s}^{-2}$ at the top. The resistance to the car's motion is 1000 N. Find

(i) the car's gain in kinetic energy, [5]

(ii) the work done by the car's engine. [3]

11 An object of mass 12 kg slides down a line of greatest slope of a smooth plane inclined at 10° to the horizontal. The object passes through points A and B with speeds $3\,\mathrm{m\,s^{-1}}$ and $7\,\mathrm{m\,s^{-1}}$ respectively.

43-N-12

(i) Find the increase in kinetic energy of the object as it moves from A to B. [2]

(ii) Hence find the distance AB, assuming there is no resisting force acting on the object. [3]

The object is now pushed up the plane from B to A, with constant speed, by a horizontal force.

(iii) Find the magnitude of this force. [3]

12 A small ball of mass 0.4 kg is released from rest at a point 5 m above horizontal ground. At the instant the ball hits the ground it loses 12.8 J of kinetic energy and starts to move upwards.

43-J-14-(4)

(i) Show that the greatest height above the ground that the ball reaches after hitting the ground is 1.8 m. [4]

(ii) Find the time taken for the ball's motion from its release until reaching this greatest height. [3]

13 A car of mass 800 kg is moving up a hill inclined at $\theta°$ to the horizontal, where $\sin\theta = 0.15$. The initial speed of the car is $8\,\text{m s}^{-1}$. Twelve seconds later the car has travelled 120 m up the hill and has speed $14\,\text{m s}^{-1}$.

(i) Find the change in the kinetic energy and the change in gravitational potential energy of the car. [3]

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(ii) The engine of the car is working at a constant rate of 32 kW. Find the total work done against the resistive forces during the twelve seconds. [3]

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