

Chapter 4 Energy, Work and Power

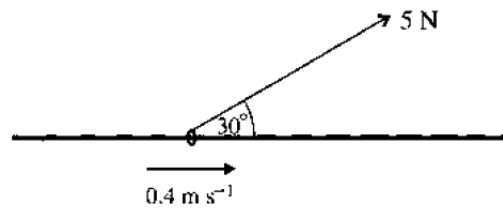
Online Classes : Megalecture@gmail.com

May/June 2002

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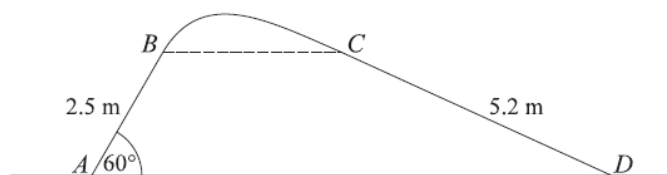
One end of a light inextensible string is attached to a ring which is threaded on a fixed horizontal bar. The string is used to pull the ring along the bar at a constant speed of 0.4 m s^{-1} . The string makes a constant angle of 30° with the bar and the tension in the string is 5 N (see diagram). Find the work done by the tension in 10 s . [3]

- 6 (i) A lorry P of mass $15\,000 \text{ kg}$ climbs a straight hill of length 800 m at a steady speed. The hill is inclined at 2° to the horizontal. For P 's journey from the bottom of the hill to the top, find
- (a) the gain in gravitational potential energy, [2]
 - (b) the work done by the driving force, which has magnitude 7000 N , [1]
 - (c) the work done against the force resisting the motion. [2]
- (ii) A second lorry, Q , also has mass $15\,000 \text{ kg}$ and climbs the same hill as P . The motion of Q is subject to a constant resisting force of magnitude 900 N , and Q 's speed falls from 20 m s^{-1} at the bottom of the hill to 10 m s^{-1} at the top. Find the work done by the driving force as Q climbs from the bottom of the hill to the top. [5]

May/June 2003

- 1 A crate of mass 800 kg is lifted vertically, at constant speed, by the cable of a crane. Find
- (i) the tension in the cable, [1]
 - (ii) the power applied to the crate in increasing the height by 20 m in 50 s . [3]

7



The diagram shows a vertical cross-section $ABCD$ of a surface. The parts AB and CD are straight and have lengths 2.5 m and 5.2 m respectively. AD is horizontal, and AB is inclined at 60° to the horizontal. The points B and C are at the same height above AD . The parts of the surface containing AB and BC are smooth. A particle P is given a velocity of 8 m s^{-1} at A , in the direction AB , and it subsequently reaches D . The particle does not lose contact with the surface during this motion.

- (i) Find the speed of P at B . [4]
- (ii) Show that the maximum height of the cross-section, above AD , is less than 3.2 m . [2]
- (iii) State briefly why P 's speed at C is the same as its speed at B . [1]
- (iv) The frictional force acting on the particle as it travels from C to D is 1.4 N . Given that the mass of P is 0.4 kg , find the speed with which P reaches D . [4]

May/June

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- 4 The top of an inclined plane is at a height of 0.7 m above the bottom. A block of mass 0.2 kg is released from rest at the top of the plane and slides a distance of 2.5 m to the bottom. Find the kinetic energy of the block when it reaches the bottom of the plane in each of the following cases:
- (i) the plane is smooth. [2]
 - (ii) the coefficient of friction between the plane and the block is 0.15. [5]
- 6 A car of mass 1200 kg travels along a horizontal straight road. The power of the car's engine is 20 kW. The resistance to the car's motion is 400 N.
- (i) Find the speed of the car at an instant when its acceleration is 0.5 m s^{-2} . [4]
 - (ii) Show that the maximum possible speed of the car is 50 m s^{-1} . [2]
- The work done by the car's engine as the car travels from a point A to a point B is 1500 kJ.
- (iii) Given that the car is travelling at its maximum possible speed between A and B , find the time taken to travel from A to B . [2]

May/June 2005

- 1 A small block is pulled along a rough horizontal floor at a constant speed of 1.5 m s^{-1} by a constant force of magnitude 30 N acting at an angle of θ° upwards from the horizontal. Given that the work done by the force in 20 s is 720 J, calculate the value of θ . [3]
- 7 A car of mass 1200 kg travels along a horizontal straight road. The power provided by the car's engine is constant and equal to 20 kW. The resistance to the car's motion is constant and equal to 500 N. The car passes through the points A and B with speeds 10 m s^{-1} and 25 m s^{-1} respectively. The car takes 30.5 s to travel from A to B .
- (i) Find the acceleration of the car at A . [4]
 - (ii) By considering work and energy, find the distance AB . [8]

May/June 2006

- 6 A block of mass 50 kg is pulled up a straight hill and passes through points A and B with speeds 7 m s^{-1} and 3 m s^{-1} respectively. The distance AB is 200 m and B is 15 m higher than A . For the motion of the block from A to B , find
- (i) the loss in kinetic energy of the block, [2]
 - (ii) the gain in potential energy of the block. [2]
- The resistance to motion of the block has magnitude 7.5 N.
- (iii) Find the work done by the pulling force acting on the block. [2]
- The pulling force acting on the block has constant magnitude 45 N and acts at an angle α° upwards from the hill.
- (iv) Find the value of α . [3]

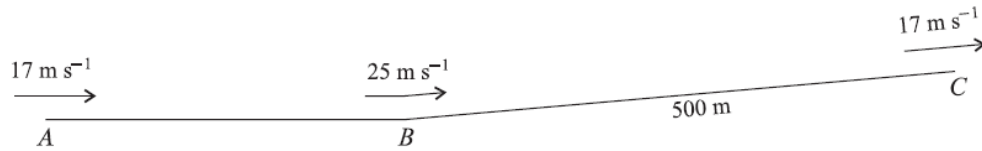
May/June 2007

- 3 A car travels along a horizontal straight road with increasing speed until it reaches its maximum speed of 30 m s^{-1} . The resistance to motion is constant and equal to $R\text{N}$, and the power provided by the car's engine is 18 kW .

(i) Find the value of R . [3]

(ii) Given that the car has mass 1200 kg , find its acceleration at the instant when its speed is 20 m s^{-1} . [3]

5



A lorry of mass $12\,500 \text{ kg}$ travels along a road that has a straight horizontal section AB and a straight inclined section BC . The length of BC is 500 m . The speeds of the lorry at A , B and C are 17 m s^{-1} , 25 m s^{-1} and 17 m s^{-1} respectively (see diagram).

(i) The work done against the resistance to motion of the lorry, as it travels from A to B , is 5000 kJ . Find the work done by the driving force as the lorry travels from A to B . [4]

(ii) As the lorry travels from B to C , the resistance to motion is 4800 N and the work done by the driving force is 3300 kJ . Find the height of C above the level of AB . [4]

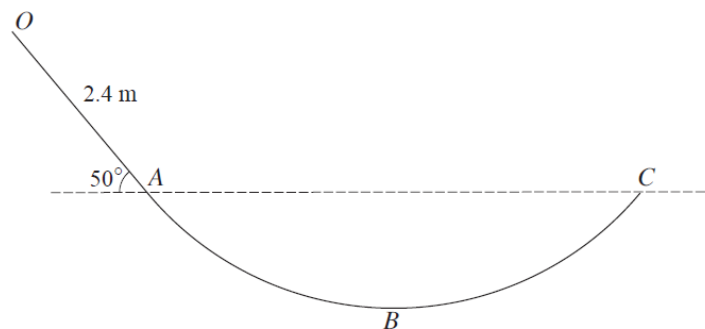
May/June 2008

- 2 A block is being pulled along a horizontal floor by a rope inclined at 20° to the horizontal. The tension in the rope is 851 N and the block moves at a constant speed of 2.5 m s^{-1} .

(i) Show that the work done on the block in 12 s is approximately 24 kJ . [3]

(ii) Hence find the power being applied to the block, giving your answer to the nearest kW . [1]

4



$OABC$ 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]

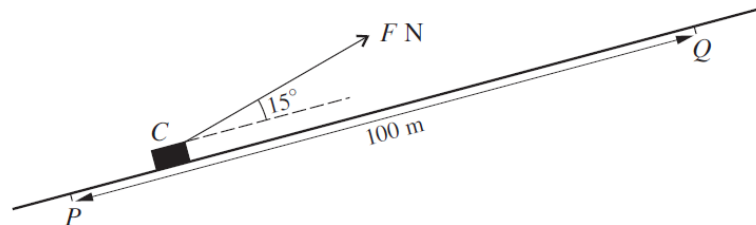
The greatest speed of P is 8 m s^{-1} .

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

- 6 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]

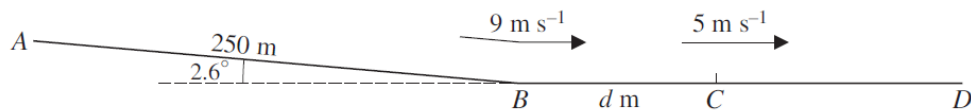
May/June 2009

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A crate C is pulled at constant speed up a straight inclined path by a constant force of magnitude $F \text{ N}$, acting upwards at an angle of 15° to the path. C passes through points P and Q which are 100 m apart (see diagram). As C travels from P to Q the work done against the resistance to C 's motion is 900 J , and the gain in C 's potential energy is 2100 J . Write down the work done by the pulling force as C travels from P to Q , and hence find the value of F . [3]

5



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 m 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 $d \text{ m}$. His speed at C is 5 m 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]