1. A brother and sister take the same time to run up a set of steps. The sister has a greater mass than her brother. Which of the following is correct?

	Has done the most work	Has developed the greatest power
A.	brother	brother
B.	brother	sister
C.	sister	brother
D.	sister	sister

(Total 1 mark)

2. A nuclear power station produces 10 GW of electrical power. The power generated by the nuclear reactions in the core of the reactor is 25 GW. The efficiency of the power station is

A. 15 %.

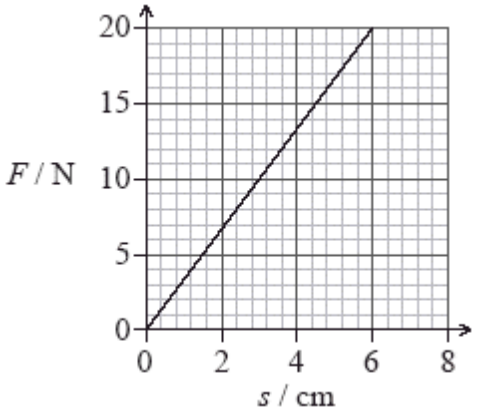
B. 35 %.

C. 40 %.

D. 60 %.

(Total 1 mark)

3. The graph shows the variation with force *F* of the extension *s* of a spring.



The work done in changing the extension of the spring from 3.0 cm to 6.0 cm is

A. 15 N cm.

B. 30 N cm.

C. 45 N cm.

D. 60 N cm.

(Total 1 mark)

4. Which of the following is a correct definition of work?

A. Product of force and distance

B. Product of force and distance moved in the direction of the force

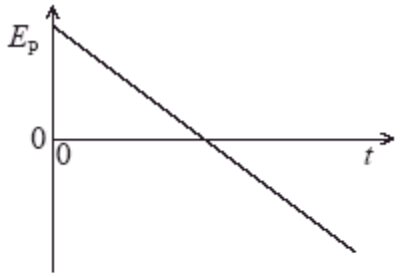
C. Product of power and time

D. Product of force and displacement

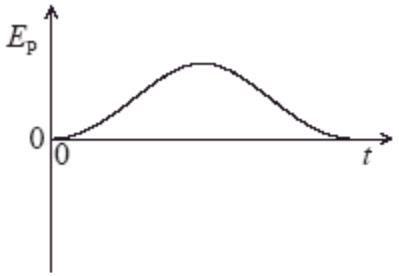
(Total 1 mark)

5. A ball is thrown vertically upwards and comes down again. Air resistance is negligible. Which of the following graphs shows how the gravitational potential energy E_P varies with time t?

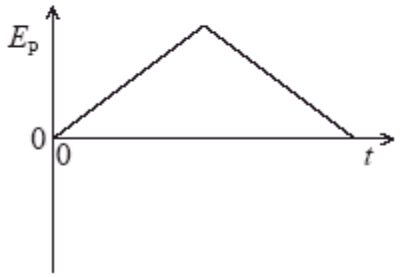
A.



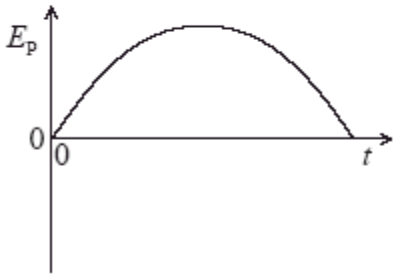
B.



C.

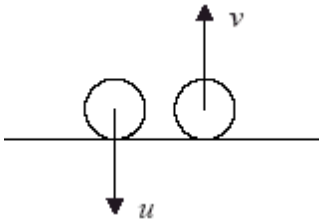


D.



(Total 1 mark)

6. A ball falls vertically and bounces off the ground. Immediately before impact with the ground the speed of the ball is *u*. Immediately after leaving the ground the speed is *v*.



Which of the following expressions is the ratio of $\frac{\text{kinetic energy lost on collision}}{\text{kinetic energy immediately before collision}}$?

A. $\frac{v}{u}$

B. $1-\frac{v}{u}$

C. $\left(\frac{v}{u}\right)^2$

D. $1-\left(\frac{v}{u}\right)^2$

(Total 1 mark)

7. A railway engine of mass *m* moves along a horizontal track with uniform speed *v*. The total resistive force acting on the engine is *F*.

Which of the following is the power of the engine?

A. $\frac{F}{mv}$

B. Fv

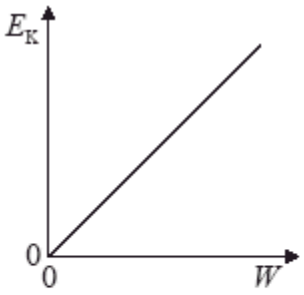
C. $\frac{mv}{F}$

D. $\frac{v}{F}$

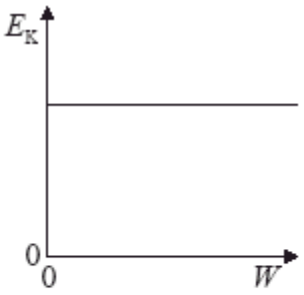
(Total 1 mark)

8. A constant force acts on a mass that is initially at rest. Which of the following graphs best shows how the kinetic energy E_K of the mass changes with the work *W* done on the mass? Friction is negligible.

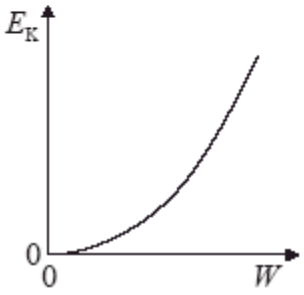
A.



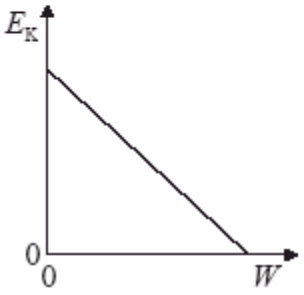
B.



C.



D.



(Total 1 mark)

9. A vehicle is driven up a hill at constant speed. Which of the following best describes the energy changes involved?

A. Chemical energy is converted into gravitational potential energy.

B. Chemical energy is converted into gravitational potential energy, sound and thermal energy.

C. Gravitational potential energy is converted into chemical energy.

D. Gravitational potential energy is converted into chemical energy, sound and thermal energy.

(Total 1 mark)

10. A vehicle is driven up a hill at constant speed. Which of the following best describes the energy changes involved?

A. Chemical energy is converted into gravitational potential energy.

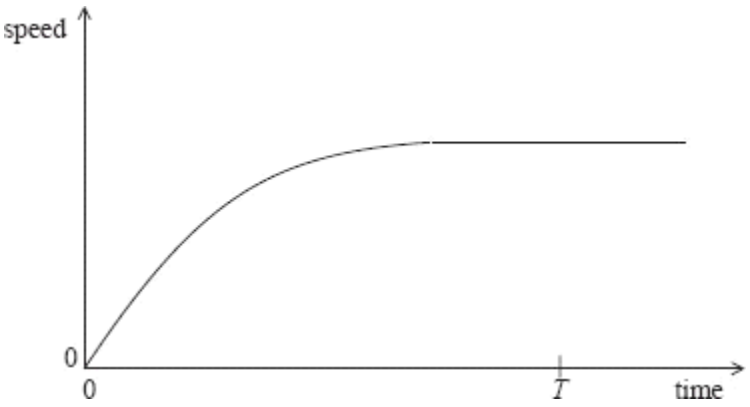
B. Chemical energy is converted into gravitational potential energy, sound and thermal energy.

C. Gravitational potential energy is converted into chemical energy.

D. Gravitational potential energy is converted into chemical energy, sound and thermal energy.

(Total 1 mark)

11. The variation with time of the vertical speed of a ball falling in air is shown below.



During the time from 0 to T, the ball gains kinetic energy and loses gravitational potential energy ΔE_p. Which of the following statements is true?

A. ΔE_p is equal to the gain in kinetic energy.

B. ΔE_p is greater than the gain in kinetic energy.

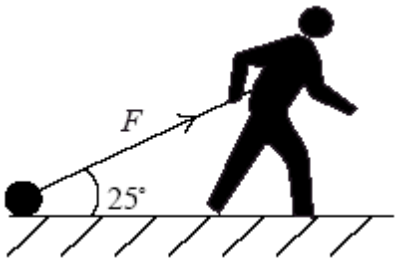
C. ΔE_p is equal to the work done against air resistance.

D. ΔE_p is less than the work done against air resistance.

(Total 1 mark)

12. This question is about forces.

An athlete trains by dragging a heavy load across a rough horizontal surface.



The athlete exerts a force of magnitude F on the load at an angle of 25° to the horizontal.

(a) Once the load is moving at a steady speed, the average horizontal frictional force acting on the load is 470 N.

Calculate the average value of *F* that will enable the load to move at constant speed.

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(2)

(b) The load is moved a horizontal distance of 2.5 km in 1.2 hours.

Calculate

(i) the work done on the load by the force *F*.

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(2)

(ii) the minimum average power required to move the load.

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(2)

(c) The athlete pulls the load uphill at the same speed as in part (a).

Explain, in terms of energy changes, why the minimum average power required is greater than in (b)(ii).

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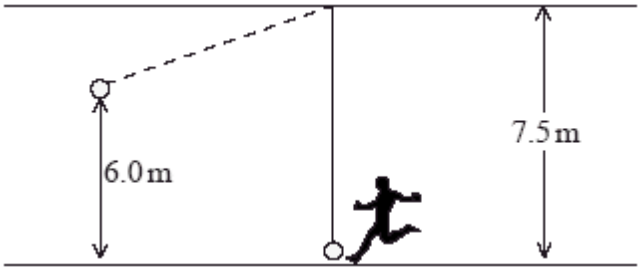
(2)

(Total 8 marks)

13. This question is about kicking a football.

A ball is suspended from a ceiling by a string of length 7.5 m. The ball is kicked horizontally and rises to a maximum height of 6.0 m.



(a) Assuming that the air resistance is negligible, show that the initial speed of the ball is 11 m s^{-1}.

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(2)

(b) The mass of the ball is 0.55 kg and the impact time of the kicker's foot with the ball is 150 ms. Estimate the average force exerted on the ball by the kick.

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(2)

(c) (i) Explain why the tension in the string increases immediately after the ball is kicked.

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(3)

(ii) Calculate the tension in the string immediately after the ball is kicked. Assume that the string is vertical.

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(3)
(Total 10 marks)

14. This question is about momentum, energy and power.

(a) In his *Principia Mathematica* Newton expressed his third law of motion as "to every action there is always opposed an equal reaction". State what Newton meant by this law.

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(1)

(b) A book is released from rest and falls towards the surface of Earth. Discuss how the conservation of momentum applies to the Earth-book system.

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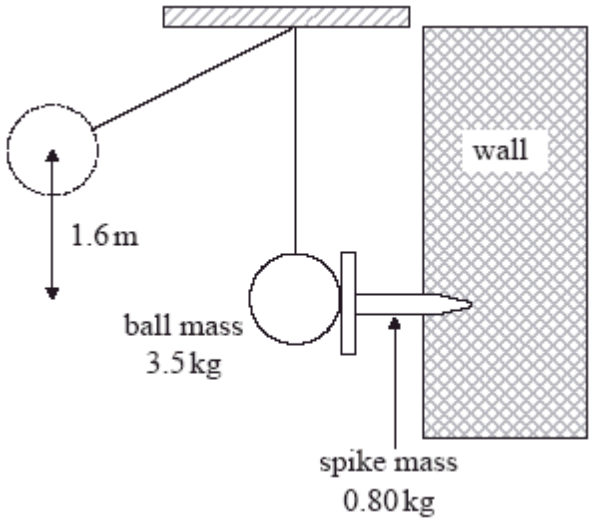
(3)

(c) A large swinging ball is used to drive a horizontal iron spike into a vertical wall. The centre of the ball falls through a vertical height of 1.6 m before striking the spike in the position shown.



The mass of the ball is 3.5 kg and the mass of the spike is 0.80 kg. Immediately after striking the spike, the ball and spike move together. Show that the

(i) speed of the ball on striking the spike is 5.6 m s^{-1}.

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(1)

(ii) energy dissipated as a result of the collision is about 10 J.

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(4)

(d) As a result of the ball striking the spike, the spike is driven a distance 7.3×10^{-2} m into the wall. Calculate, assuming it to be constant, the friction force F between the spike and wall.

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(3)

(e) The machine that is used to raise the ball has a useful power output of 18 W. Calculate how long it takes for the machine to raise the ball through a height of 1.6 m.

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(3)
(Total 15 marks)

15. Mechanical power

(a) Define *power*.

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(1)

(b) A car is travelling with constant speed v along a horizontal straight road. There is a total resistive force F acting on the car.

Deduce that the power P to overcome the force F is $P = Fv$.

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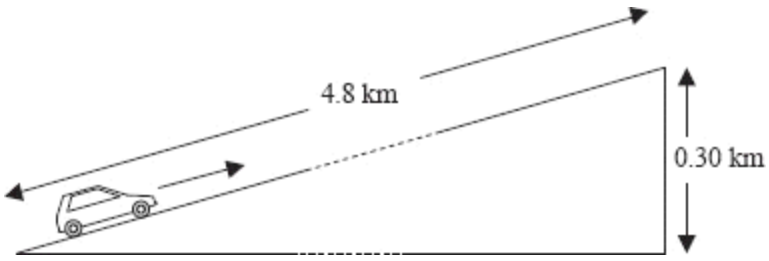
(2)

(c) A car drives up a straight incline that is 4.8 km long. The total height of the incline is 0.30 km.



The car moves up the incline at a steady speed of 16 m s^{-1}. During the climb, the average friction force acting on the car is 5.0×10^2 N. The total weight of the car and the driver is 1.2×10^4 N.

(i) Determine the time it takes the car to travel from the bottom to the top of the incline.

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(2)

(ii) Determine the work done against the gravitational force in travelling from the bottom to the top of the incline.

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(1)

(iii) Using your answers to (c)(i) and (c)(ii), calculate a value for the minimum power output of the car engine needed to move the car from the bottom to the top of the incline.

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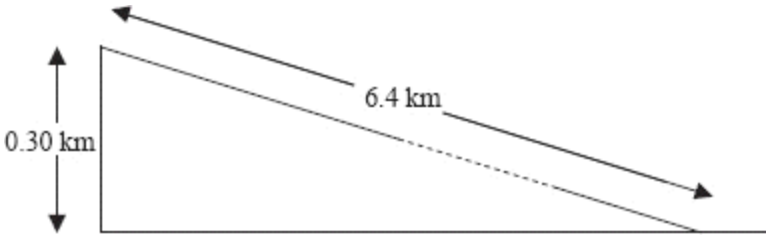
(4)

(d) From the top of the incline, the road continues downwards in a straight line. At the point where the road starts to go downwards, the driver of the car in (c), stops the car to look at the view. In continuing his journey, the driver decides to save fuel. He switches off the engine and allows the car to move freely down the hill. The car descends a height of 0.30 km in a distance of 6.4 km before levelling out.



The average resistive force acting on the car is 5.0×10^2 N.

Estimate

(i) the acceleration of the car down the incline.

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(5)

(ii) the speed of the car at the bottom of the incline.

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(2)

(e) In fact, for the last few hundred metres of its journey down the hill, the car travels at constant speed. State the value of the frictional force acting on the car whilst it is moving at constant speed.

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(1)

(Total 18 marks)