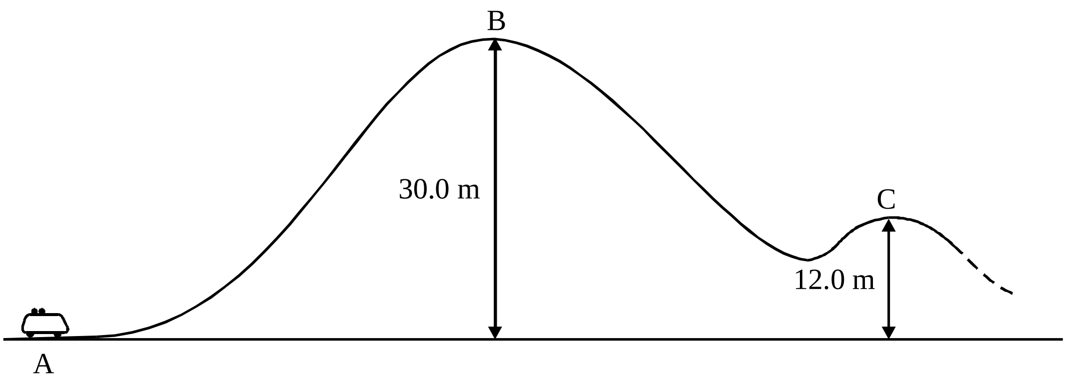
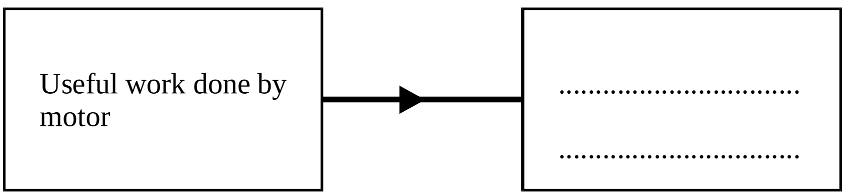
Energy, Work & Power Questions

24. The diagram shows part of a roller coaster ride. **In practice, friction and air resistance will have a significant effect on the motion of the vehicle, but you should ignore them throughout this question**.



The vehicle starts from rest at A and is hauled up to B by a motor. It takes 15.0 S to reach B, at which point its speed is negligible. Complete the box in the diagram below, which expresses the conservation of energy for the journey from A to B.



(1)

The mass of the vehicle and the passengers is 3400 kg. Calculate

(i) the useful work done by the motor.

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....

Work done = ...

(ii) the power output of the motor.

....

....

Power = ...

(4)

At point B the motor is switched off and the vehicle moves under gravity for the rest of the ride. Describe the overall energy conversion which occurs as it travels from B to C.

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(1)

Calculate the speed of the vehicle at point C.

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....

....

Speed = ...

(3)

On another occasion there are fewer passengers in the vehicle; hence its total mass is less than before. Its speed is again negligible at B. State with a reason how, if at all, you would expect the speed at C to differ from your previous answer.

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(2)
(Total 11 marks)

25. An athlete of mass 55.0 kg runs up a flight of stairs of vertical height 3.60 m in 1.80 s.

Calculate the gain in gravitational potential energy of the athlete in doing this.

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....

....

Gain in g.p.e. =…………………………………………………..

Calculate the power that this athlete develops in doing this.

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Power =…………………………………………………

(4)

One way of comparing athletes of different sizes is to compare their power-to-weight ratios.
Find a unit for the power-to-weight ratio in terms of SI base units.

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(2)

Calculate the athlete's power-to-weight ratio.

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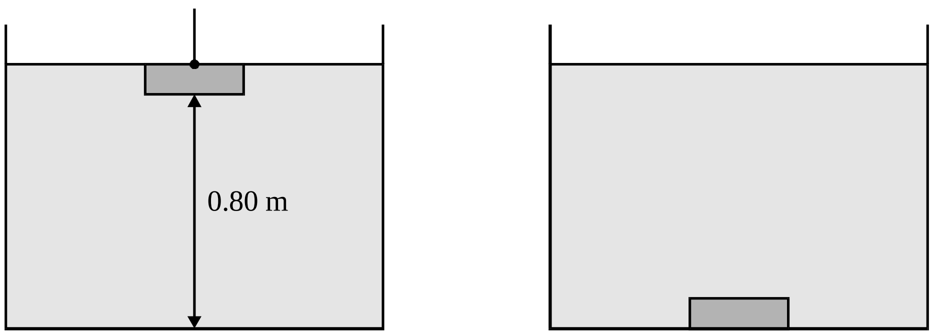
Power-to-weight ratio =…………………………………………………

(2)
(Total 8 marks)

26. A granite block is suspended at rest just below the surface of water in a tank (Figure i).
The block is now released and falls 0.80 m to the bottom (Figure ii).

Figure (i) **Figure (ii)**



The volume of the block is 3.0×10^{-3} m^3, and the density of granite is 2700 kg m^{-3}.
Calculate the gravitational potential energy lost by the block as it falls.

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....

....

g.p.e. = ...

(3)

Although the water level has not changed, the water has gained gravitational potential energy. Explain why.

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....

(1)

The gravitational potential energy gained by the water is less than that lost by the granite block. Explain this.

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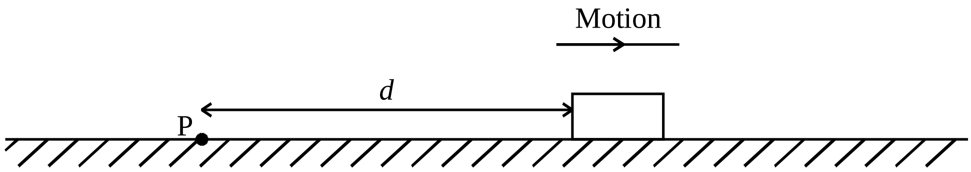
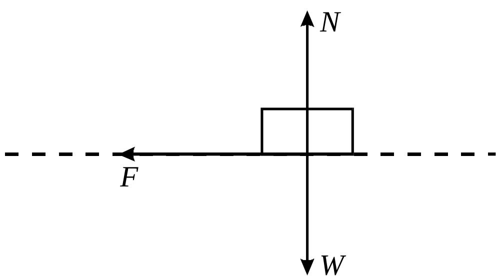
(2)
(Total 6 marks)

27. A block is projected from a point P across a rough, horizontal surface.



The block slows down under the influence of a constant frictional force *F* and eventually comes to rest. Below is a free-body force diagram for the block whilst it is moving.



State, with a reason, the amount of work done by each of the forces *W* and *N* as the block moves across the surface.

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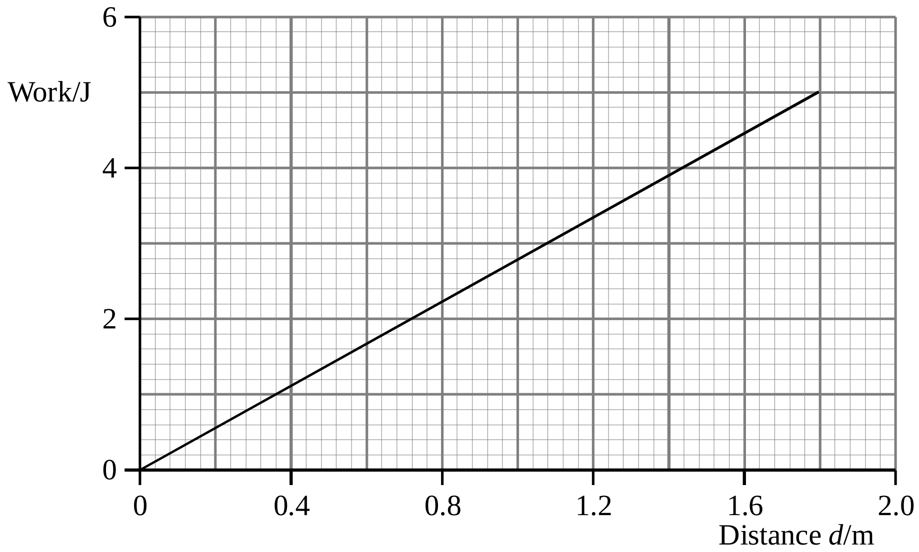
(2)

The sliding block does work against friction. The graph shows how the total work done varies with the distance *d* which the block has travelled from the projection point P.



Use the graph to determine the force *F*.

....

....

....

F = ...

(2)

The block comes to rest 1.80 m from P. Add a line to the graph above to show how the kinetic energy of the block varied during the motion.

(2)

The mass of the block was 0.820 kg. Calculate the speed with which it was projected from P.

....

....

....

Speed = ...

(2)

Suppose that, instead of a constant friction force, the block had been brought to rest by a drag force (air resistance) which depends on speed. On the axes below sketch a graph to show qualitatively how you would expect the total work done against air resistance to vary with the distance *d*.

(1)

Explain the shape of your graph.

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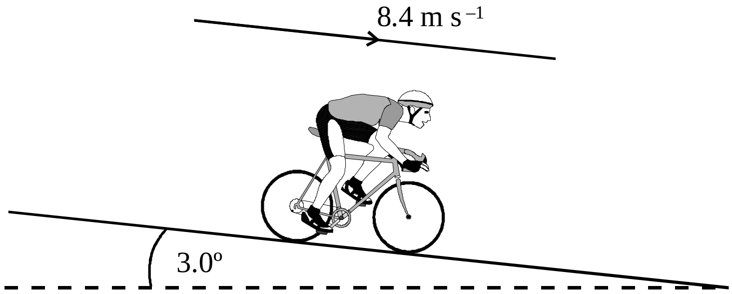
....

(1)
(Total 10 marks)

28. A cyclist is free-wheeling down a long slope which is at 3.0° to the horizontal. He is travelling, without pedalling, at a constant speed of 8.4 m s^{-1}.



The combined mass of the cyclist and bicycle is 90 kg. Calculate the gravitational potential energy (g.p.e.) lost per second.

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G.p.e. lost per second = ...

(3)

What happens to this lost g.p.e.?

....

....

(1)

At the bottom of the slope the cyclist turns round and pedals back up at the same steady speed of 8.4 m s^{-1}. Give an estimate of the rate at which the cyclist does work as he climbs the hill.

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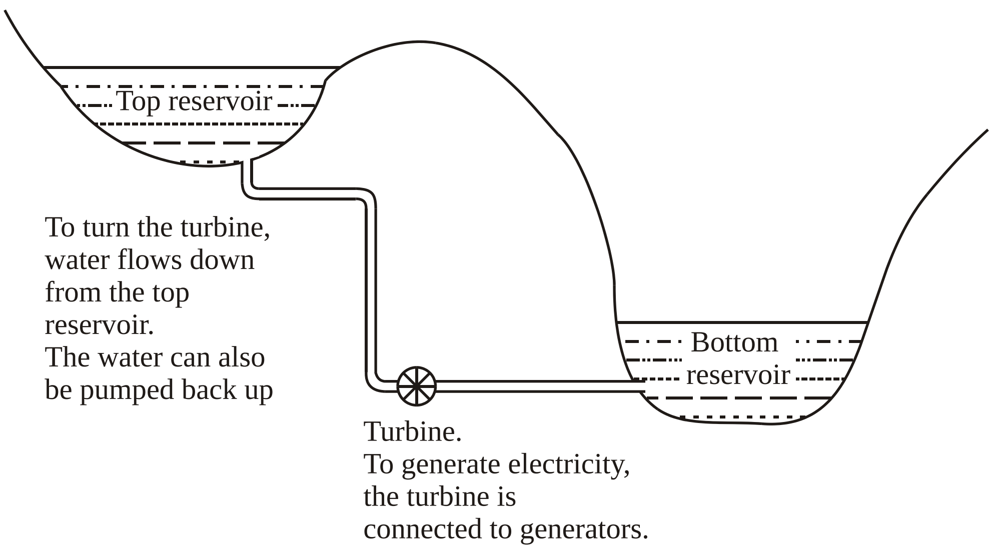
Rate of working = ...

(2)
(Total 6 marks)

29. A certain power station generates electricity from falling water. The diagram shows a simplified sketch of the system.



(a) (i) In what form is the energy of the water initially stored?

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(ii) What energy form is this transformed into in order to drive the turbine?

....

(1)

(b) State the principal of conservation of energy.

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....

....

(2)

(c) The force of the water at the turbine is 3.5×10^8 N and the output power generated is 1.7×10^9 W. Use this data to calculate the minimum speed at which the water must enter the turbine.

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....

(2)

(d) Explain why, in practice, the speed at which the water enters the turbine is much greater than this.

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(1)

(e) When working at this output power, 390 m^3 of water flows through the turbine each second. The top reservoir holds 7.0×10^6 m^3 of water. For how long will electricity be generated?

....

....

....

Time = ...

(1)

(f) This power station is used at peak periods, after which the water is pumped back to the top reservoir. The water has to be raised by 500 m. How much work is done to return all the water to the top reservoir?

(The density of water is 1000 kg m^{-3}.)

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Work done = ...

(3)
(Total 10 marks)

30. (a) A car of mass *m* is travelling in a straight line along a horizontal road at a speed *u* when the driver applies the brakes. They exert a constant force *F* on the car to bring the car to rest after a distance *d*.

(i) Write down expressions for the initial kinetic energy of the car and the work done by the brakes in bringing the car to rest.

Kinetic energy ....

Work done ....

(1)

(ii) Show that the base units for your expressions for kinetic energy and work done are the same.

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....

(2)

(b) A car is travelling at 13.4 m s^{-1}. The driver applies the brakes to decelerate the car at 6.5 m s^{-2}. Show that the car travels about 14 m before coming to rest.

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(3)

(c) On another occasion, the same car is travelling at twice the speed. The driver again applies the brakes and the car decelerates at 6.5 m s^{-2}. The car travels just over 55 m before coming to rest. Explain why the braking distance has more than doubled. You may be awarded a mark for the clarity of your answer.

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(4)
(Total 10 marks)

31. A weightlifter raised a bar of mass of 110 kg through a height of 2.22 m. The bar was then dropped and fell freely to the floor.

(i) Show that the work done in raising the bar was about 2400 J.

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(2)

(ii) It took 3.0 s to raise the bar. Calculate the average power used.

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....

Power = ……………………………………

(2)

(iii) State the principle of conservation of energy.

....

....

....

(2)

(iv) Describe how the principle of conservation of energy applies to

(1) lifting the bar,

(2) the bar **falling** to the floor. Do not include the impact with the floor.

(1) ....

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(2) ....

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(3)

(v) Calculate the speed of the bar at the instant it reaches the floor.

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Speed = ……………………………………

(3)
(Total 12 marks)