Q1. In an experiment to measure the power output of a motor, the motor is used to lift a metal block vertically at constant speed.

You may be awarded marks for the quality of written communication in your answers.

(a) Describe an experiment to check whether the speed of the rising mass is constant.

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(2)

(b) Explain how the output power of the motor is calculated, stating what measurements need to be made.

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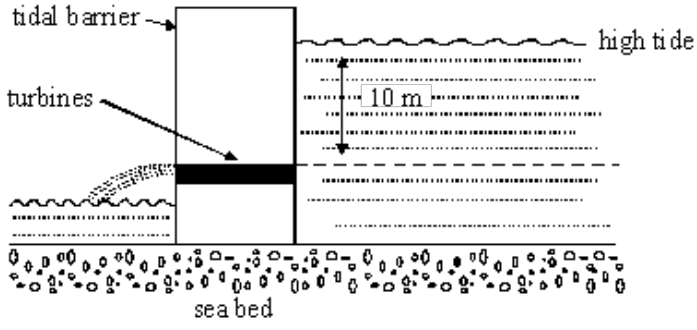
(2)
(Total 4 marks)

Q2. Tidal power could make a significant contribution to UK energy requirements. This question is about a tidal power station which traps sea water behind a tidal barrier at high tide and then releases the water through turbines 10.0 m below the high tide mark.



(i) Calculate the mass of sea water covering an area of 120 km^2 and depth 10.0 m.

density of sea water = 1100 kg m^{-3}

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(ii) Calculate the maximum loss of potential energy of the sea water in part (i) when it is released through the turbines.

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(iii) The potential energy of the sea water released through the turbines, calculated in part (ii), is lost over a period of 6.0 hours. Estimate the average power output of the power station over this time period. Assume the power station efficiency is 40%.

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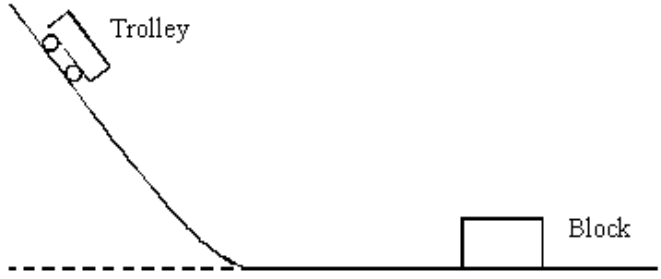
(Total 7 marks)

Q3. The diagram represents an experiment that can be used to investigate stopping distances for a moving trolley.



The trolley is placed on the raised section of the track. When released it moves down the track and then travels along the horizontal section before colliding with the block. The trolley and block join and move together after the collision. The distance they move is measured.

(a) State the main energy changes taking place

(i) as the trolley descends,

.....

(ii) after the collision, as the trolley and block move together.

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(2)

(b) Describe how the speed of the trolley, just before it collides with the block may be measured experimentally.

You may be awarded marks for the quality of written communication in your answer.

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(3)

(c) State and explain how the speed of the trolley, prior to impact could be varied.

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(2)

(Total 7 marks)

Q4. A skydiver of mass 70 kg, jumps from a stationary balloon and reaches a speed of 45 m s^{-1} after falling a distance of 150 m.

(a) Calculate the skydiver's

(i) loss of gravitational potential energy,

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(ii) gain in kinetic energy.

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(4)

(b) The difference between the loss of gravitational potential energy and the gain in kinetic energy is equal to the work done against air resistance. Use this fact to calculate

(i) the work done against air resistance,

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(ii) the average force due to air resistance acting on the skydiver.

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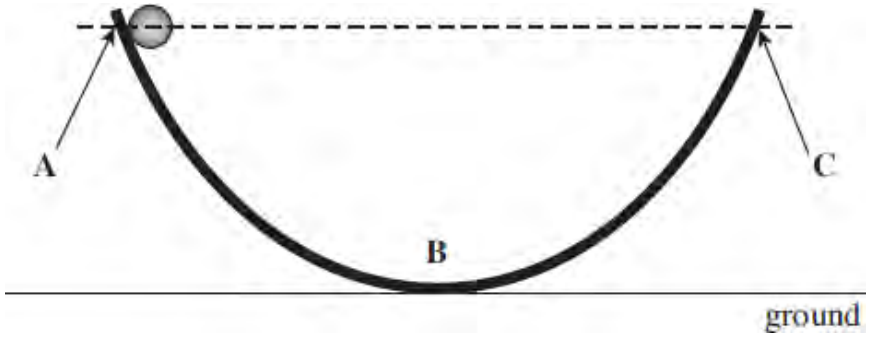
(3)
(Total 7 marks)

Q5. In the 17th century, when thinking about forces, Galileo imagined a ball moving in the absence of air resistance on a frictionless track as shown in **Figure 1**.

Figure 1



(a) Galileo thought that, under these circumstances, the ball would reach position **C** if released from rest at position **A**. Position **C** is the same height above the ground as **A**.

Using ideas about energy, explain why Galileo was correct.

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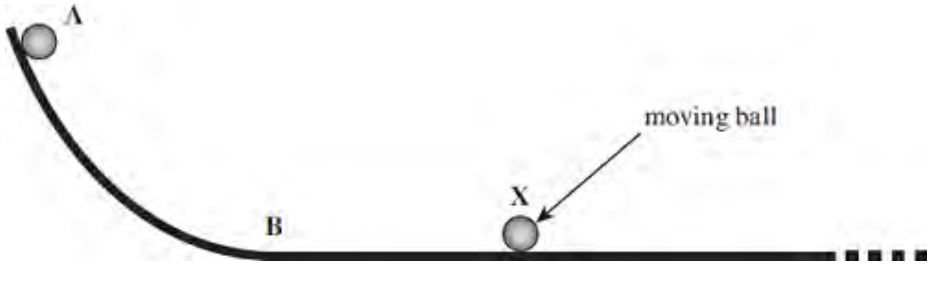
(3)

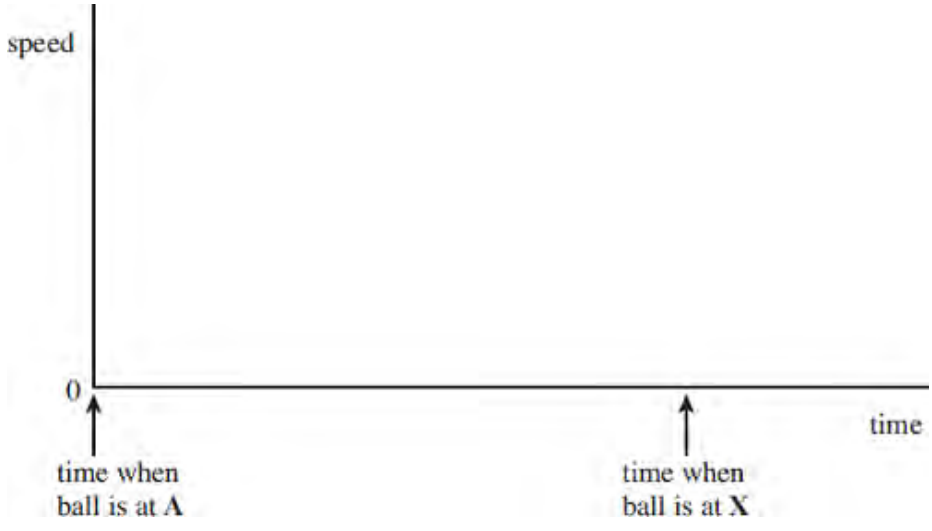
(b) Galileo then imagined that the track was changed, as shown in **Figure 2**.

Figure 2



The slope beyond **B** was now horizontal.

On the axes below, sketch a speed – time graph for the ball from its release at **A** until it reaches the position **X** shown in **Figure 2**. Indicate on your graph the time when the ball is at **B**.



(3)

(c) Newton later published his three laws of motion.

Explain how Newton's first law of motion is illustrated by the motion of the ball between **B** and **X**.

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(2)
(Total 8 marks)

Q6. It has been predicted that in the future large offshore wind turbines may have a power output ten times that of the largest ones currently in use. These turbines could have a blade length of 100 m or more. A turbine such as this is shown in the diagram below.

(a) At a wind speed of 11 m s^{-1} the volume of air passing through the blades each second is 3.5×10^5 m^3.

(i) Show that the mass of air that would pass through the blades each second is about 4×10^5 kg.

The density of air is 1.2 kg m^{-3}

(2)

(ii) Calculate the kinetic energy of the air that would enter the turbine each second.

answer = ... J

(2)

(iii) It has been predicted that the turbine would produce an electrical power output of 10 MW in these wind conditions. Calculate the percentage efficiency of the turbine in converting this kinetic energy into electrical energy.

answer = ... %

(2)

(b) State **one** advantage and **one** disadvantage of wind power in comparison to fossil fuel.

Advantage .....

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Disadvantage .....

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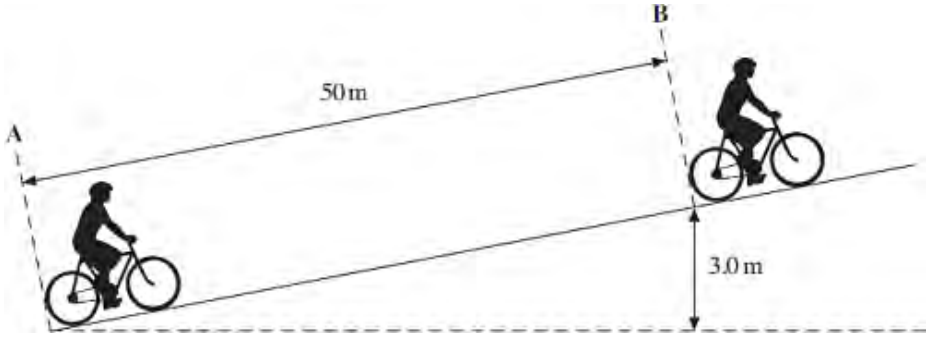
(2)

(Total 8 marks)

Q7. An 'E-bike' is a bicycle that is assisted by an electric motor. The figure below shows an E-bike and rider with a total mass of 83 kg moving up an incline.



(a) (i) The cyclist begins at rest at **A** and accelerates uniformly to a speed of 6.7 ms^{-1} at **B**. The distance between **A** and **B** is 50 m.
Calculate the time taken for the cyclist to travel this distance.

answer = ... s

(2)

(ii) Calculate the kinetic energy of the E-bike and rider when at **B**. Give your answer to an appropriate number of significant figures.

answer = ... J

(2)

(iii) Calculate the gravitational potential energy gained by the E-bike and rider between **A** and **B**.

answer = ... J

(2)

(b) Between **A** and **B**, the work done by the electric motor is 3700 J, and the work done by the cyclist pedalling is 5300 J.

(i) Calculate the wasted energy as the cyclist travels from **A** to **B**.

answer = ... J

(2)

(ii) State **two** causes of this wasted energy.

Cause 1 .....

.....

Cause 2 .....

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(2)

(Total 10 marks)

Q8. The figure below shows apparatus that can be used to investigate energy changes.

The trolley and the mass are joined by an inextensible string. In an experiment to investigate energy changes, the trolley is initially held at rest, and is then released so that the mass falls vertically to the ground.

You may be awarded marks for the quality of written communication in your answer.

(a) (i) State the energy changes of the falling mass.

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(ii) Describe the energy changes that take place in this system.

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(4)

(b) State what measurements would need to be made to investigate the *conservation of energy*.

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(2)

(c) Describe how the measurements in part (b) would be used to investigate the conservation of energy.

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(4)

(Total 10 marks)

Q9. (a) Explain why a raindrop falling vertically through still air reaches a constant velocity. You may be awarded marks for the quality of written communication in your answer.

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(4)

(b) A raindrop falls at a constant vertical velocity of 1.8 m s^{-1} in still air. The mass of the raindrop is 7.2×10^{-9} kg.

Calculate

(i) the kinetic energy of the raindrop,

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(ii) the work done on the raindrop as it falls through a vertical distance of 4.5 m.

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(4)

(c) The raindrop in part (b) now falls through air in which a horizontal wind is blowing. If the velocity of the wind is 1.4 m s^{-1}, use a scale diagram or calculation to determine the magnitude and direction of the resultant velocity of the raindrop.

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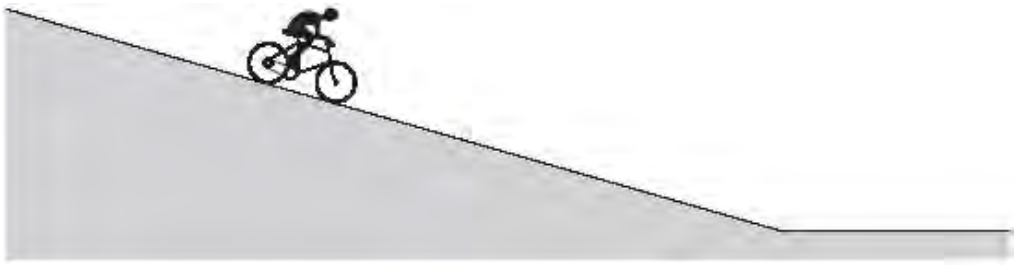
(3)

(Total 11 marks)

Q10. A cyclist **pedals** downhill on a road, as shown in the diagram below, from rest at the top of the hill and reaches a horizontal section of the road at a speed of 16 m s^{-1}. The total mass of the cyclist and the cycle is 68 kg.



(a) (i) Calculate the total kinetic energy of the cyclist and the cycle on reaching the horizontal section of the road.

answer ..... J

(2)

(ii) The height difference between the top of the hill and the horizontal section of road is 12 m.
Calculate the loss of gravitational potential energy of the cyclist and the cycle.

answer ..... J

(2)

(iii) The work done by the cyclist when pedalling downhill is 2400 J. Account for the difference between the loss of gravitational potential energy and the gain of kinetic energy of the cyclist and the cycle.

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(3)

(b) The cyclist stops pedalling on reaching the horizontal section of the road and slows to a standstill 160 m further along this section of the road. Assume the deceleration is uniform.

(i) Calculate the time taken by the cyclist to travel this distance.

answer..... s

(3)

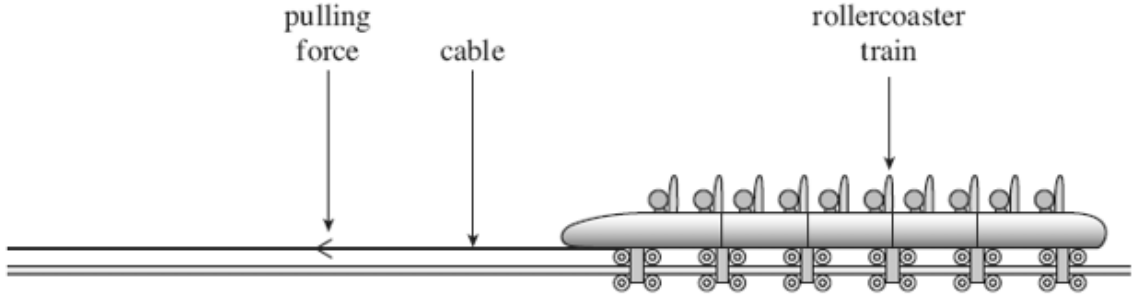
(ii) Calculate the average horizontal force on the cyclist and the cycle during this time.

answer ..... N

(3)

(Total 13 marks)

Q11. The figure below shows a rollercoaster train that is being accelerated when it is pulled horizontally by a cable.



(a) The train accelerates from rest to a speed of 58ms^{-1} in 3.5 s. The mass of the fully loaded train is 5800 kg.

(i) Calculate the average acceleration of the train.

answer = ... ms^{-2}

(ii) Calculate the average tension in the cable as the train is accelerated, stating an appropriate unit.

answer = ...

(3)

(iii) Calculate the distance the train moves while accelerating from rest to 58ms^{-1}.

answer = ... m

(2)

(iv) The efficiency of the rollercoaster acceleration system is 20%.
Calculate the average power input to this system during the acceleration.

answer = ... W

(3)

(b) After reaching its top speed the driving force is removed and the rollercoaster train begins to ascend a steep track. By considering energy transfers, calculate the height that the train would reach if there were no energy losses due to friction.

answer = ... m

(3)

(Total 13 marks)