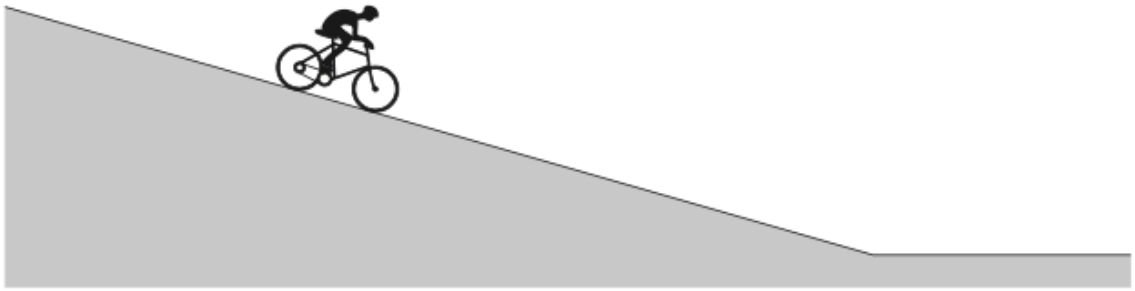
1)

A cyclist **pedals** downhill on a road, as shown in **Figure 1**, 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.

Figure 1



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

answer.....J

(2 marks)

(a) (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 marks)

(a) (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 marks)

(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.

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

answer.....s

(3 marks)

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

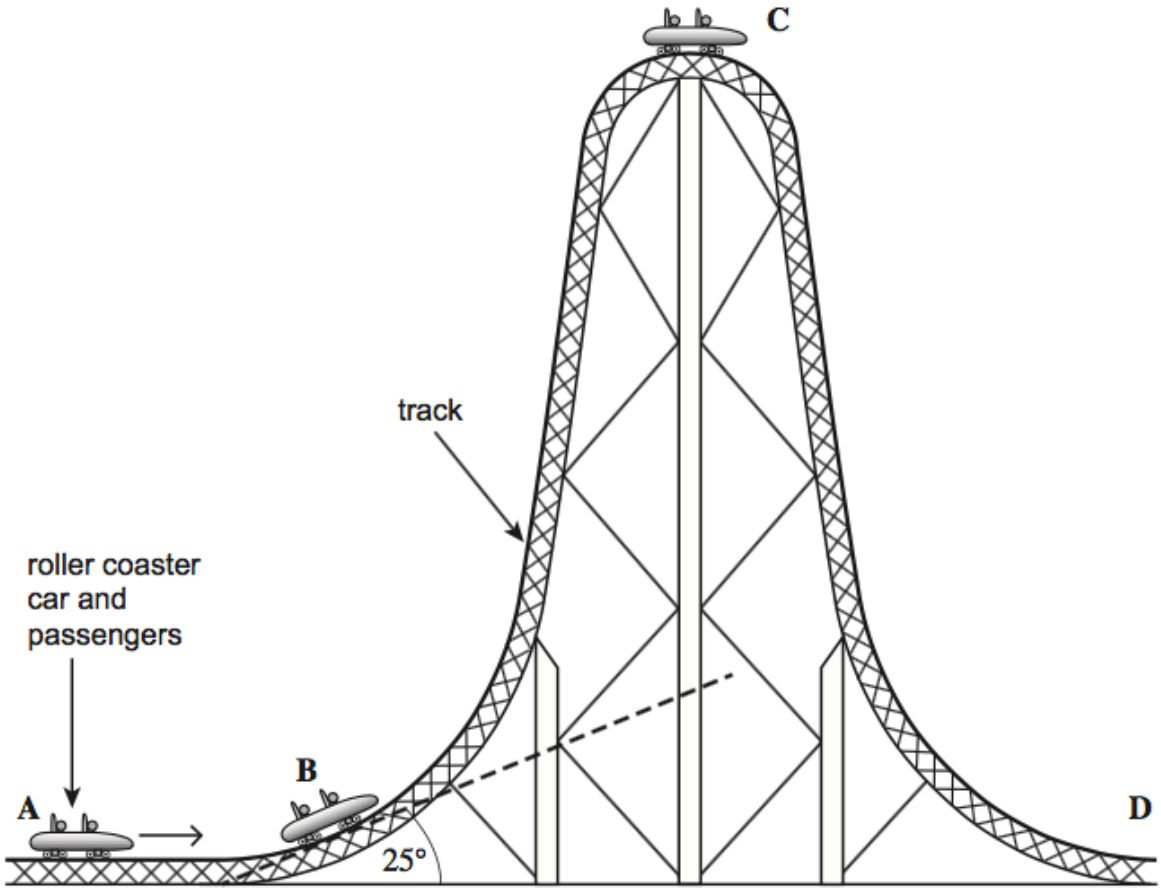
answer.....N

(3 marks)

2)

Figure 1 shows a roller coaster car which is accelerated from rest to a speed of $56\,\mathrm{m\,s^{-1}}$ on a horizontal track, **A**, before ascending the steep part of the track. The roller coaster car then becomes stationary at **C**, the highest point of the track. The total mass of the car and passengers is $8300\,\mathrm{kg}$.

Figure 1



(a) The angle of the track at **B** is 25° to the horizontal. Calculate the component of the weight of the car and passengers acting along the slope when the car and passengers are in position **B** as shown in **Figure 1**.

[2 marks]

component of weight ..... N

(b) (i) Calculate the kinetic energy of the car including the passengers when travelling at $56\,m\,s^{-1}$.

[2 marks]

kinetic energy ..... J

(b) (ii) Calculate the maximum height above **A** that would be reached by the car and passengers if all the kinetic energy could be transferred to gravitational potential energy.

[2 marks]

maximum height ..... m

(c) The car does not reach the height calculated in part (b).

(c) (i) Explain the main reason why the car does not reach this height.

[2 marks]

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(c) (ii) The car reaches point **C** which is at a height of $140\,m$ above **A**. Calculate the speed that the car would reach when it descends from rest at **C** to its original height from the ground at **D** if 87% of its energy at **C** is converted to kinetic energy.

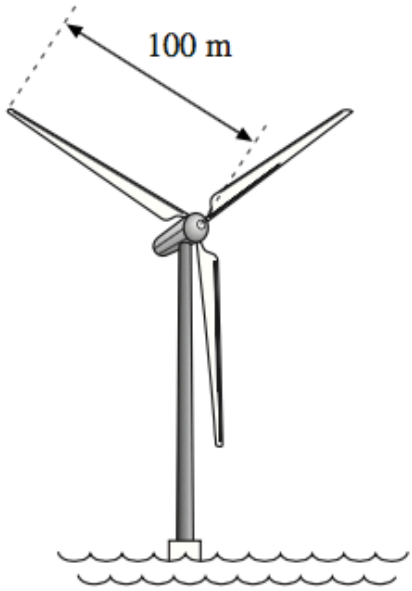
[2 marks]

speed ..... $m\,s^{-1}$

3)

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 **Figure 8**.

Figure 8



(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.

(a) (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 marks)

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

answer = ... J
(2 marks)

(a) (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 marks)

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

Advantage .....

.....

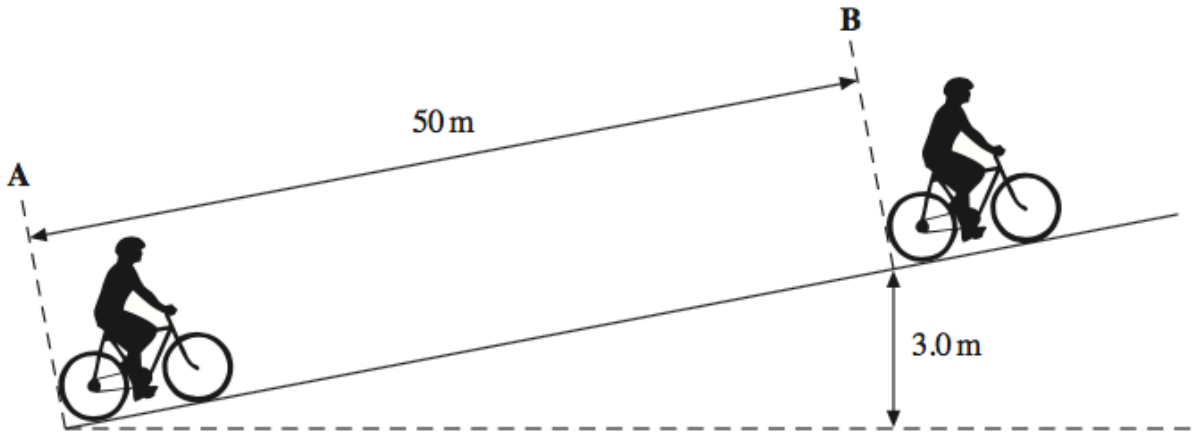
Disadvantage .....

.....
(2 marks)

4)

An 'E-bike' is a bicycle that is assisted by an electric motor. **Figure 2** shows an E-bike and rider with a total mass of 83 kg moving up an incline.

Figure 2



(a) (i) The cyclist begins at rest at **A** and accelerates uniformly to a speed of 6.7 m s^{-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 marks)

(a) (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 marks)

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

answer = ... J

(2 marks)

(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.

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

answer = ... J

(2 marks)

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

Cause 1 .....

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Cause 2 .....

.....

(2 marks)

5)

The world record for a high dive into deep water is 54 m.

(a) Calculate the loss in gravitational potential energy (gpe) of a diver of mass 65 kg falling through 54 m.

loss in gpe = ... J

(2 marks)

(b) Calculate the vertical velocity of the diver the instant before he enters the water. Ignore the effects of air resistance.

velocity = ... $m\,s^{-1}$

(2 marks)

(c) Calculate the time taken for the diver to fall 54 m. Ignore the effects of air resistance.

time = ... s

(2 marks)

(d) Explain, with reference to energy, why the velocity of the diver is independent of his mass if air resistance is insignificant.

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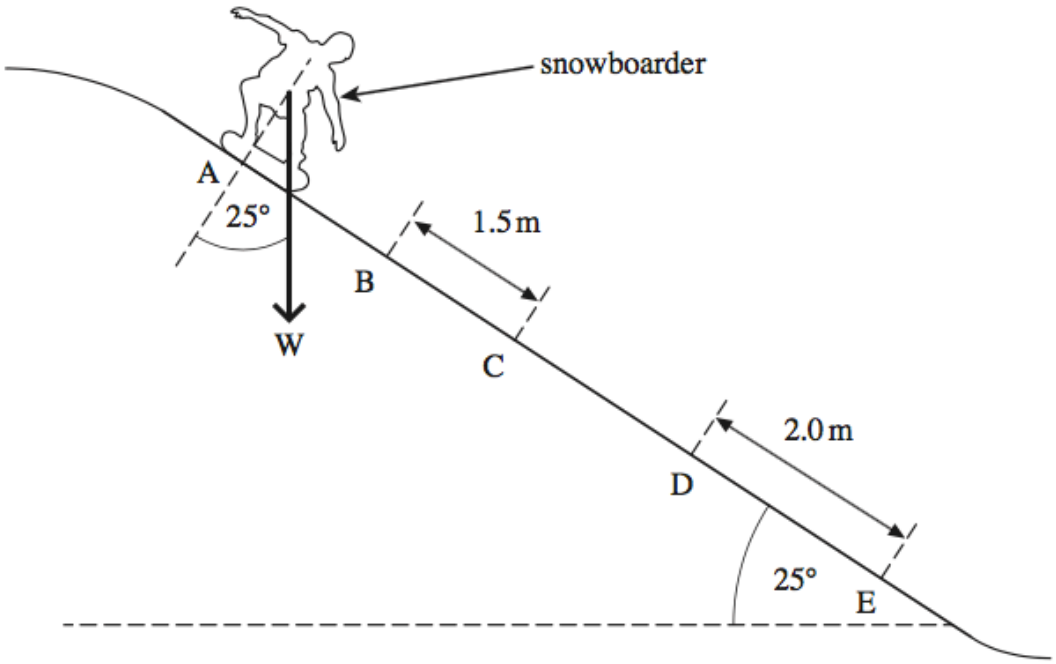
(3 marks)

6)

A snowboarder slides down a slope, as shown in **Figure 1**. Between **B** and **C** her acceleration is uniform.

Figure 1



(a) The snowboarder travels 1.5 m from B to C in a time of 0.43 s and her velocity down the slope at C is 5.0 m s^{-1}.

Calculate her velocity down the slope at B.

velocity = ... m s^{-1}
(3 marks)

(b) The combined mass of the snowboarder and snowboard is 75 kg and the angle of the slope is 25°.

(b) (i) Calculate the component of the weight of the snowboarder and snowboard acting down the slope.

weight component = ... N
(2 marks)

(b) (ii) At D the snowboarder has reached a constant velocity. She moves a distance of 2.0 m at constant velocity between D and E.

Calculate the work done against resistive forces as she moves from D to E.

work done = ... J

(1 mark)

(c) State and explain what happens to the gravitational potential energy lost between D and E.

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(3 marks)