Q1. The diagram below shows an electric two-wheeled vehicle and driver.

(a) The vehicle accelerates horizontally from rest to 27.8 m s^{-1} in a time of 4.6 s. The mass of the vehicle is 360 kg and the rider has a mass of 82 kg.

(i) Calculate the average acceleration during the 4.6 s time interval.
Give your answer to an appropriate number of significant figures.

acceleration = ... m s^{-2}

(2)

(ii) Calculate the average horizontal resultant force on the vehicle while it is accelerating.

resultant force = ... N

(2)

(b) State and explain how the horizontal forward force on the vehicle has to change for **constant** acceleration to be maintained from 0 to 27.8 m s^{-1}.

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(3)

(c) The electric motors drive both wheels of the vehicle.

Add labelled force arrows to the diagram to show the horizontal forces acting on the vehicle when it is moving at a constant speed.

(2)

(d) The vehicle now accelerates to a constant speed of 55 m s^{-1}. The useful power output of the motors is 22 kW at this speed.

Calculate the horizontal resistive force acting on the vehicle.

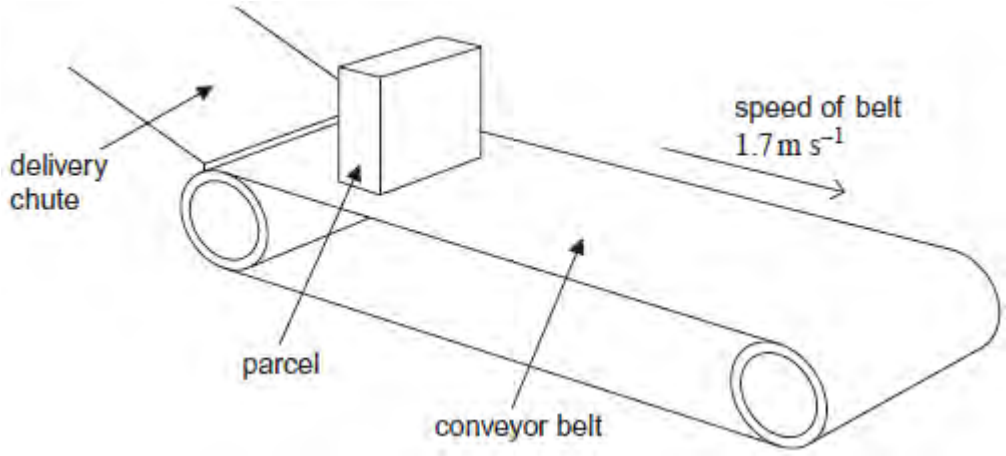
horizontal resistive force = ... N

(2)

(Total 11 marks)

Q2.(a) A parcel of mass 15 kg drops from a delivery chute onto a conveyor belt as shown in **Figure 1**.
The belt is moving at a steady speed of 1.7 m s^{-1}.
The parcel lands on the moving belt with negligible speed and initially starts to slip. It takes 0.82 s for the parcel to gain enough speed to stop slipping and move at the same speed as the conveyor belt.

Figure 1



(i) Calculate the change in kinetic energy of the parcel during the first 0.82 s.

change in kinetic energy ..... J

(2)

(ii) The average horizontal force acting on the parcel during the first 0.82 s is 31 N.

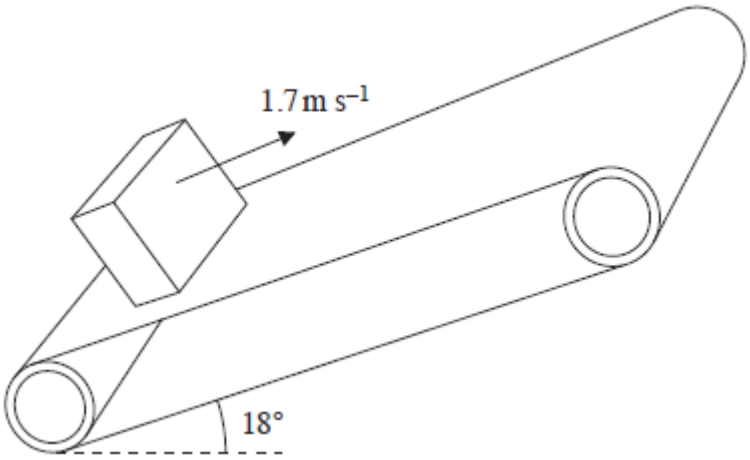
Calculate the horizontal distance between the parcel and the end of the delivery chute 0.82 s after the parcel lands on the conveyor belt. Assume that the parcel does not reach the end of the conveyor belt.

horizontal distance ..... m

(2)

(b) At a later stage the parcel is being raised by another conveyor belt as shown in **Figure 2**.

Figure 2



This conveyor belt is angled at 18° to the horizontal and the parcel moves at a steady speed of 1.7 m s^{-1} without slipping.

Calculate the rate at which work is done on the parcel.

rate at which work is done ..... W

(3)
(Total 7 marks)

Q3. A firework rocket is fired vertically into the air and explodes at its highest point. What are the changes to the total kinetic energy of the rocket and the total momentum of the rocket as a result of the explosion?

	total kinetic energy of rocket	**total momentum of rocket**	
A	unchanged	unchanged	⬭
B	unchanged	increased	⬭
C	increased	unchanged	⬭
D	increased	increased	⬭

(Total 1 mark)

Q4. Which of the following is **not** a unit of power?

A $N\ m\ s^{-1}$ ⬭

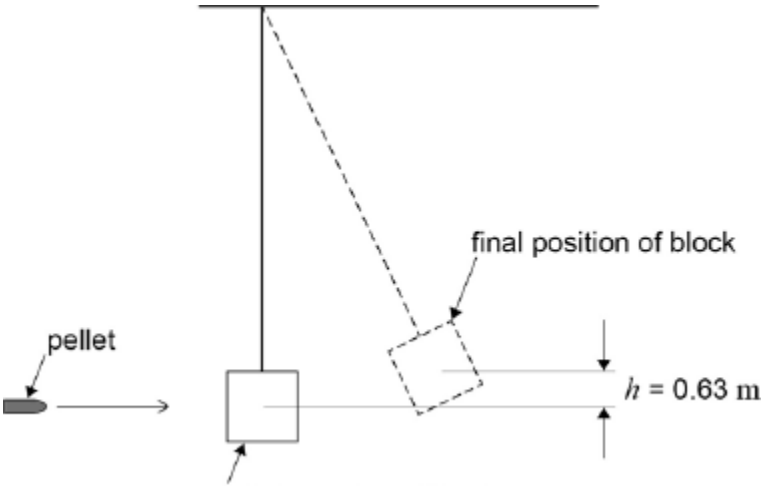
B $kg\ m^2\ s^{-3}$ ⬭

C $J\ s^{-1}$ ⬭

D $kg\ m^{-1}\ s^{-1}$ ⬭

(Total 1 mark)

Q5. The speed of an air rifle pellet is measured by firing it into a wooden block suspended from a rigid support.
The wooden block can swing freely at the end of a light inextensible string as shown in the figure below.



A pellet of mass 8.80 g strikes a stationary wooden block and is completely embedded in it. The centre of mass of the block rises by 0.63 m. The wooden block has a mass of 450 g.

(a) Determine the speed of the pellet when it strikes the wooden block.

speed = ... m s^{-1}

(4)

(b) The wooden block is replaced by a steel block of the same mass.
The experiment is repeated with the steel block and an identical pellet. The pellet rebounds after striking the block.

Discuss how the height the steel block reaches compares with the height of 0.63 m reached by the wooden block. In your answer compare the energy and momentum changes that occur in the two experiments.

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(4)

(c) Discuss which experiment is likely to give the more accurate value for the velocity of the pellet.

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(2)
(Total 10 marks)

Q6. A car exerts a driving force of 500 N when travelling at a constant speed of72 km h^{-1} on a level track. What is the work done in 5 minutes?

A 3.0×10^6 J ⬭

B 2.0×10^6 J ⬭

C 2.0×10^5 J ⬭

D 1.1×10^5 J ⬭

(Total 1 mark)

Q7. An electric motor of input power 100 W raises a mass of 10 kg vertically at a steady speed of 0.5 m s^{-1}. What is the efficiency of the system?

A 5% ⬭

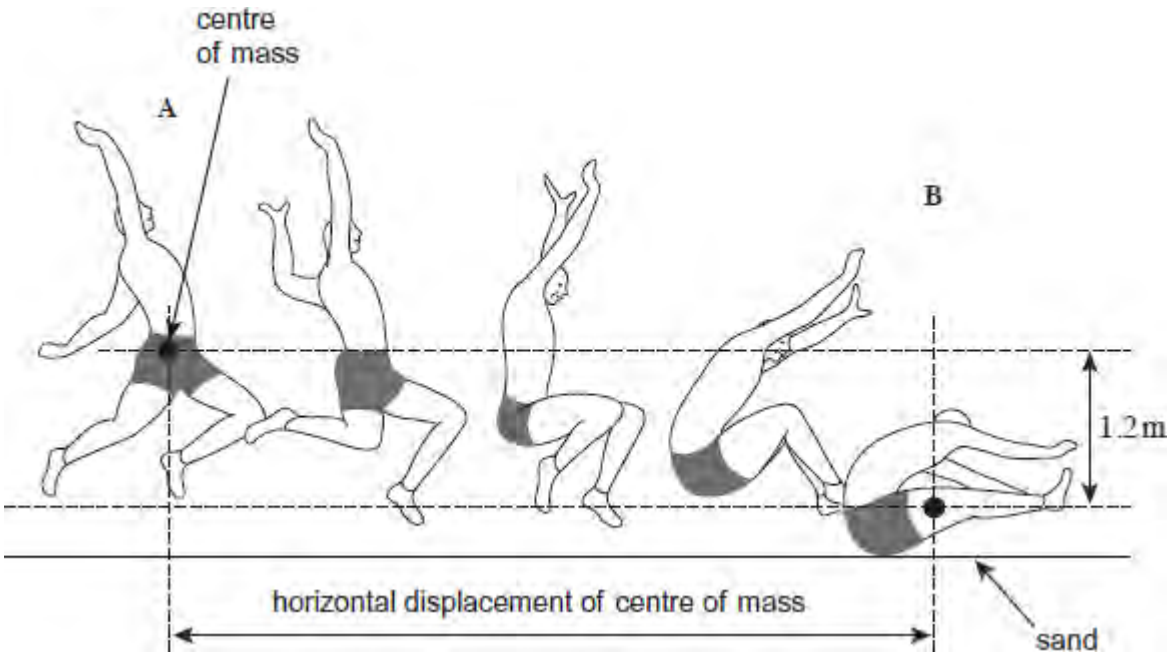
B 12% ⬭

C 50% ⬭

D 100% ⬭

(Total 1 mark)

Q8. The motion of a long jumper during a jump is similar to that of a projectile moving under gravity. The figure below shows the path of an athlete above the ground during a long jump from half-way through the jump at position **A**, to position **B** at which contact is made with sand on the ground. The athlete is travelling horizontally at **A**.



(a) During this part of the jump, the centre of mass of the athlete falls 1.2 m.

(i) Calculate the time between positions **A** and **B**.

time ..... s

(3)

(ii) The athlete is moving horizontally at **A** with a velocity of 8.5 m s^{-1}. Assume

there is noair resistance. Calculate the horizontal displacement of the centre of mass from **A** to **B**.

horizontal displacement ..... m

(2)

(b) (i) The athlete in the image above slides horizontally through the sand a distance of 0.35 m before stopping.

Calculate the time taken for the athlete to stop. Assume the horizontal component of the resistive force from the sand is constant.

time ..... s

(2)

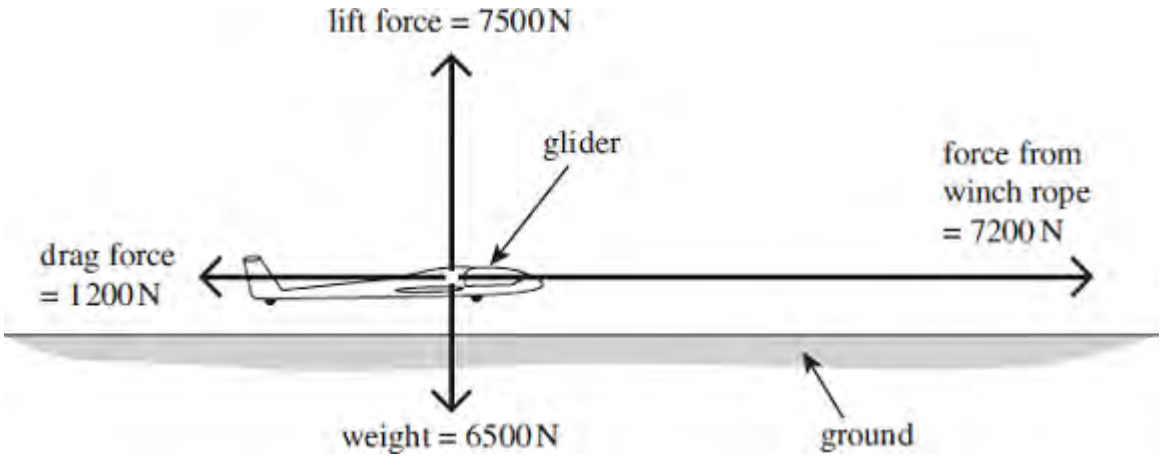
(ii) The athlete has a mass of 75 kg. Calculate the horizontal component of the resistive force from the sand.

horizontal component of resistive force ..... N

(3)

(Total 10 marks)

Q9. Gliders can be launched with a winch situated on the ground. The winch pulls a rope that is attached to the glider. The diagram below shows the forces acting on the glider at one instant during the launch.



(a) The combined weight of the glider and pilot is 6500 N.

(i) Show that the magnitude of the resultant force acting on the glider is about 6100 N.

(2)

(ii) Calculate the angle between this resultant force and the horizontal.

angle ..... degrees

(2)

(iii) Calculate the resultant acceleration of the glider in the diagram above.

resultant acceleration ..... m s^{-2}

(2)

(b) The glider climbs a vertical distance of 600 m in 55 s. The average power input to the winch motor during the launch is 320 kW.

(i) Calculate the gain in gravitational potential energy (gpe) of the glider.

gain in gpe ..... J

(2)

(ii) Calculate the percentage efficiency of the winch system used to launch the glider. Assume the kinetic energy of the glider after the launch is negligible.

efficiency ..... %

(3)

(Total 11 marks)