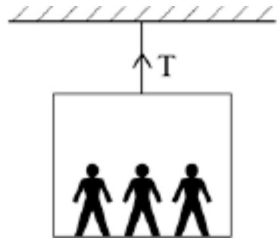
1 A lift and its passengers with a total mass of 500 kg accelerates upwards at 2 m s^{-2} as shown. Assume that g = 10 m s^{-2}.



What is the tension in the cable?

A 1000 N

B 4000 N

C 5000 N

D 6000 N

(Total 1 mark)

2 The mass of fuel in a racing car decreases during a race. As a result the lap time decreases.

Which of the following could explain this decrease?

A there is less friction on the race track

B the maximum speed of the car has increased

C the maximum acceleration and deceleration are greater

D the engine is more efficient

(Total 1 mark)

3 Which of the following statements is correct?

The force acting on an object is equivalent to

A its change of momentum.

B the impulse it receives per second.

C the energy it gains per second.

D its acceleration per metre.

(Total 1 mark)

4 A car of mass 1300 kg is stopped by a constant horizontal braking force of 6.2 kN.

(a) Show that the deceleration of the car is about 5 m s^{-2}.

(3)

(b) The initial speed of the car is 27 m s^{-1}.
Calculate the distance travelled by the car as it decelerates to rest.

distance travelled ____________________ m

(3)
(Total 6 marks)

5 The Thrust SSC car raised the world land speed record in 1997. The mass of the car was 1.0×10^4 kg. A 12 s run by the car may be considered in two stages of constant acceleration. Stage one was from 0 to 4.0 s and stage two 4.0 s to 12 s.

(a) In stage one the car accelerates from rest to 44 m s^{-1} in 4.0 s. Calculate the acceleration produced and the force required to accelerate the car.

(b) In stage two the car continued to accelerate so that it reached 280 m s^{-1} in a further 8.0 s.
Calculate the acceleration of the car during stage two.

___

___

(c) Calculate the distance travelled by the car from rest to reach a speed of 280 m s^{-1}.

___

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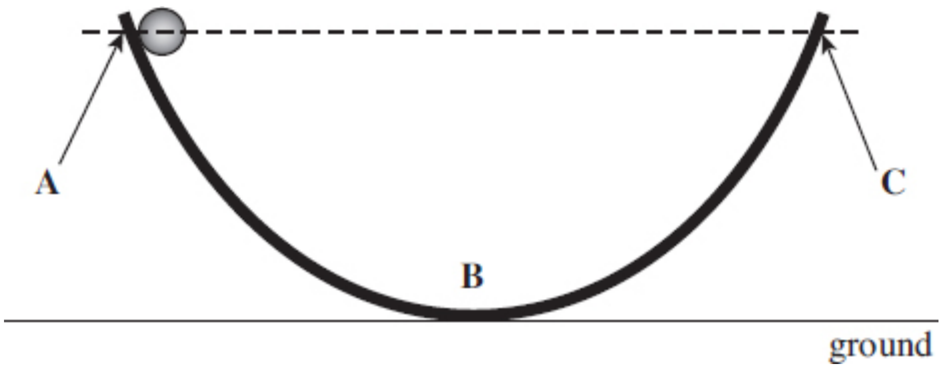
(Total 6 marks)

6 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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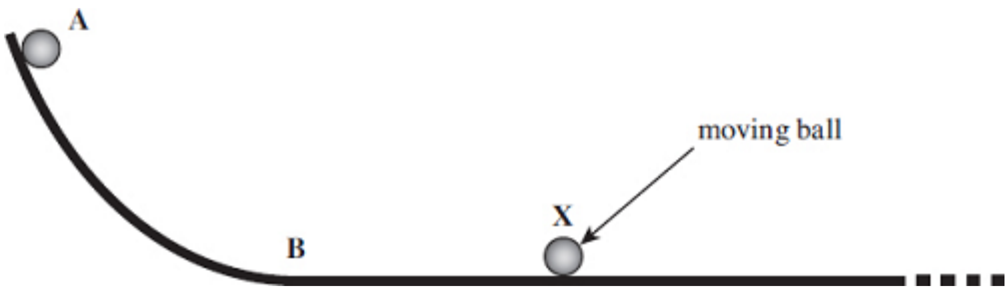
(3)

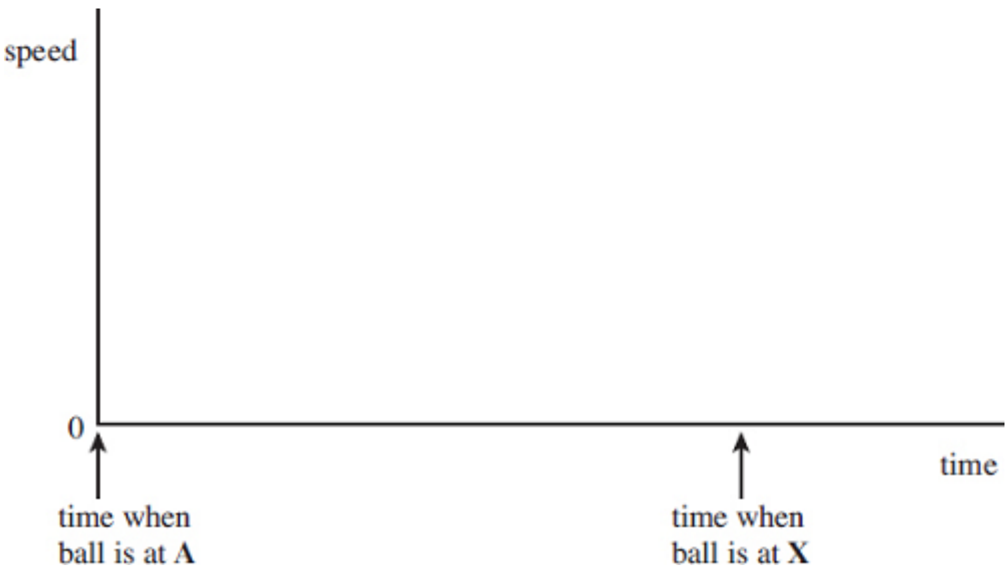
(b) Galileo then imagined that the track was changed, as shown in **Figure 2**.

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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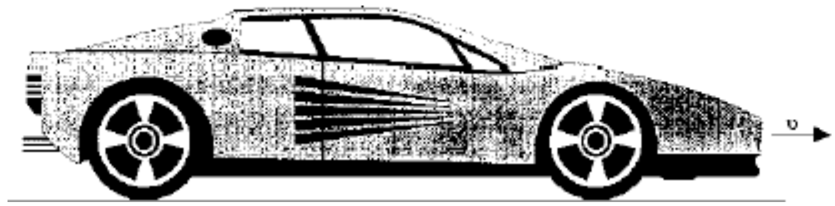
(2)

(Total 8 marks)

7 The diagram shows a car travelling at a constant velocity along a horizontal road.



(a) (i) Draw and label arrows on the diagram representing the forces acting on the car.

(ii) Referring to Newton's Laws of motion, explain why the car is travelling at constant velocity.

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(5)

(b) The car has an effective power output of 18 kW and is travelling at a constant velocity of 10 m s^{-1}. Show that the total resistive force acting is 1800 N.

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(1)

(c) The total resistive force consists of two components. One of these is a constant frictional force of 250 N and the other is the force of air resistance, which is proportional to the square of the car's speed.

Calculate

(i) the force of air resistance when the car is travelling at 10 m s^{-1},

____

____

(ii) the force of air resistance when the car is travelling at 20 m s^{-1},

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____

(iii) the effective output power of the car required to maintain a constant speed of 20 m s^{-1} in a horizontal road.

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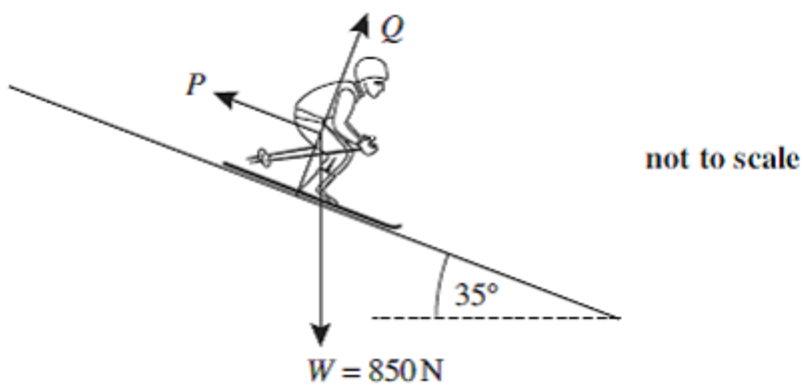
(4)

(Total 10 marks)

8 (a) **Figure 1** shows a skier travelling at constant speed down a slope of 35°. The force labelled **P** is parallel to the slope. The force labelled **Q** is perpendicular to the slope. Assume that there is no friction between the skis and the snow.

Figure 1



(i) Identify the forces labelled **P** and **Q**.

P ___

___

Q ___

___

(2)

(ii) State the condition necessary for the skier to be travelling at a constant velocity.

___

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(1)

(b) **Figure 2** shows an arrow representing the weight, W, of the skier. The arrow has been drawn to scale.

Figure 2

scale 1 cm: 100 N

By drawing the forces **P** and **Q** onto **Figure 2**, complete the scale diagram and determine the magnitude of the force **P**.

magnitude of force **P** ________________________ N

(4)

(c) (i) The skier moves onto level snow. Initially the magnitude of force **P** remains constant. The mass of the skier is 87 kg.
Calculate the initial deceleration of the skier.

____

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____

____

deceleration ________________________ ms^{-2}

(2)

(ii) State and explain what would happen to the deceleration as the skier continues along the level snow.

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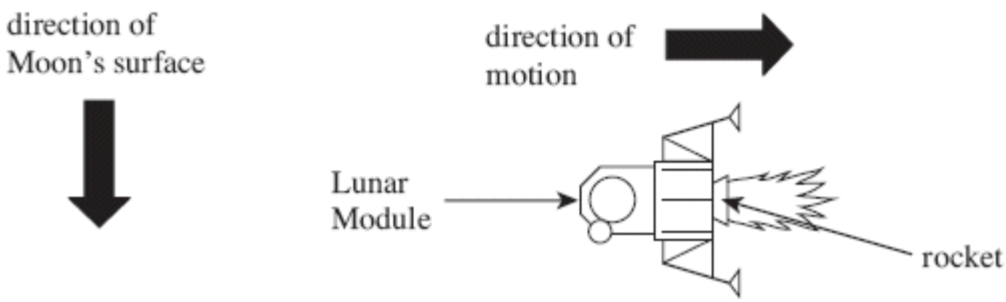
(2)

(Total 11 marks)

9 In the 1969 Moon landing, the Lunar Module separated from the Command Module above the surface of the Moon when it was travelling at a horizontal speed of 2040 m ss^{-1}.
In order to descend to the Moon's surface the Lunar Module needed to reduce its speed using its rocket as shown in **Figure 1**.

Figure 1



(a) (i) The average thrust from the rocket was 30 kN and the mass of the Lunar Module was 15100 kg. Calculate the horizontal deceleration of the Lunar Module.

answer = ______________________ m s^{-2}

(2)

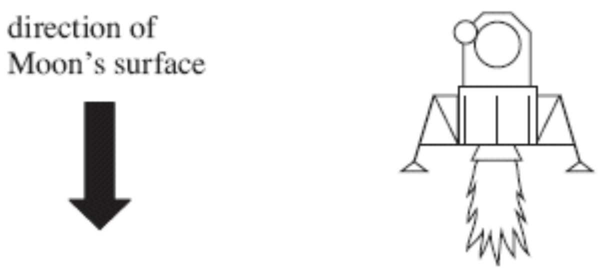
(ii) Calculate the time for the Lunar Module to slow to the required horizontal velocity of 150 m s^{-1}. Assume the mass remained constant.

answer = ______________________ s

(2)

(b) The rocket was then used to control the velocity of descent so that the Lunar Module descended vertically with a constant velocity as shown in **Figure 2**. Due to the use of fuel during the previous deceleration, the mass of the Lunar Module had fallen by 53%.

Figure 2



acceleration due to gravity near the Moon's surface = 1.61 m s^{-2}

(i) Draw force vectors on **Figure 2** to show the forces acting on the Lunar Module at this time. Label the vectors.

(2)

(ii) Calculate the thrust force needed to maintain a constant vertical downwards velocity.

answer = ______________________ N

(2)

(c) When the Lunar Module was 1.2 m from the lunar surface, the rocket was switched off. At this point the vertical velocity was 0.80 m s^{-1}. Calculate the vertical velocity at which the Lunar Module reached the lunar surface.

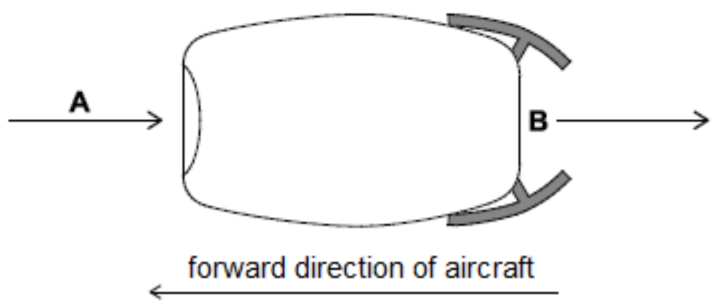
answer = ______________________ m s^{-1}

(2)

(Total 10 marks)

10 **Figure 1** shows a jet engine.

Figure 1



Air enters the engine at **A** and is heated before leaving **B** at a much higher speed.

(a) State what happens to the momentum of the air as it passes through the engine.

____

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(1)

(b) Explain, using appropriate laws of motion, why the air exerts a force on the engine in the forward direction.

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(3)

(c) In one second a mass of 210 kg of air enters at **A**. The speed of this mass of air increases by 570 m s^{-1} as it passes through the engine.

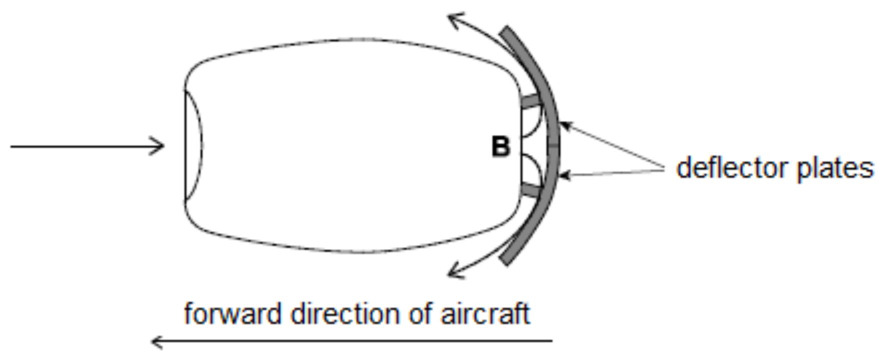
Calculate the force that the air exerts on the engine.

force = ____________________ N

(1)

(d) When an aircraft lands, its jet engines exert a decelerating force on the aircraft by making use of deflector plates. These cause the air leaving the engines to be deflected at an angle to the direction the aircraft is travelling as shown in **Figure 2**.

Figure 2



The speed of the air leaving **B** is the same as the speed of the deflected air.

Explain why the momentum of the air changes.

____

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(2)

(e) The total horizontal decelerating force exerted on the deflector plates of the jet engines is 190 kN.

Calculate the deceleration of the aircraft when it has a mass of 7.0×10^4 kg.

deceleration = ____________________ $m\ s^{-2}$

(1)

(f) The aircraft lands on the runway travelling at a speed of 68 m s^{-1} with the deflector plates acting.

Calculate the distance the aircraft travels along the runway until it comes to rest. You may assume that the decelerating force acting on the jet engines remains constant.

distance = ____________________ m

(2)

(g) Suggest why in practice the decelerating force provided by the deflector plates may not remain constant.

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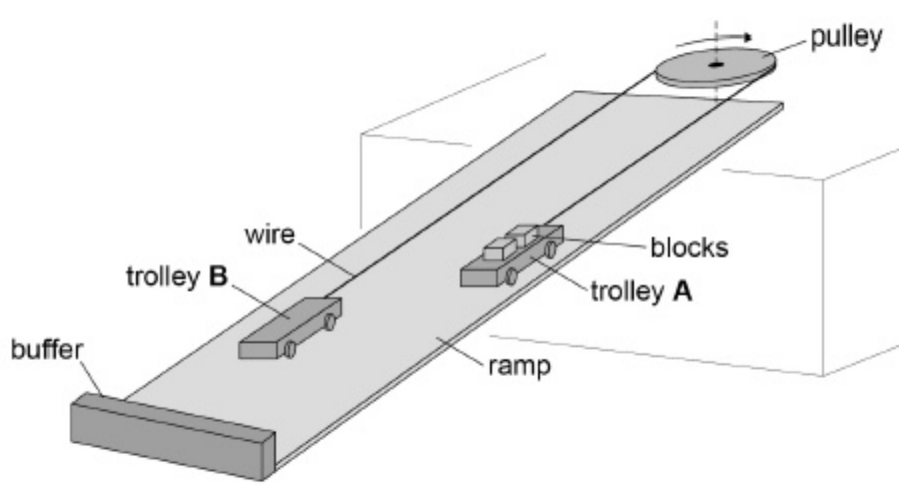
(2)

(Total 12 marks)

11 **Figure 1** shows a model of a system being designed to move concrete building blocks from an upper to a lower level.

Figure 1

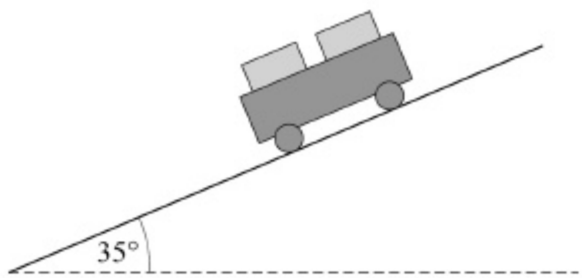


The model consists of two identical trolleys of mass *M* on a ramp which is at 35° to the horizontal. The trolleys are connected by a wire that passes around a pulley of negligible mass at the top of the ramp.

Two concrete blocks each of mass *m* are loaded onto trolley **A** at the top of the ramp. The trolley is released and accelerates to the bottom of the ramp where it is stopped by a flexible buffer. The blocks are unloaded from trolley **A** and two blocks are loaded onto trolley **B** that is now at the top of the ramp. The trolleys are released and the process is repeated.

Figure 2 shows the side view of trolley **A** when it is moving **down** the ramp.

Figure 2



(a) The tension in the wire when the trolleys are moving is T.

Draw and label arrows on **Figure 2** to represent the magnitudes and directions of any forces and components of forces that act on trolley **A** parallel to the ramp as it travels down the ramp.

(1)

(b) Assume that no friction acts at the axle of the pulley or at the axles of the trolleys and that air resistance is negligible.

Show that the acceleration a of trolley **B** along the ramp is given by

$$a = \frac{mg \sin 35^\circ}{M + m}$$

(2)

(c) Compare the momentum of loaded trolley **A** as it moves downwards with the momentum of loaded trolley **B**.

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(2)

(d) In practice, for safety reasons there is a friction brake in the pulley that provides a resistive force to reduce the acceleration to 25% of the maximum possible acceleration.

The distance travelled for each journey down the ramp is 9.0 m.

The following data apply to the arrangement.

Mass of a trolley M = 95 kg

Mass of a concrete block m = 30 kg

Calculate the time taken for a loaded trolley to travel down the ramp.

time = ____________________ s

(3)

(e) It takes 12 s to remove the blocks from the lower trolley and reload the upper trolley.

Calculate the number of blocks that can be transferred to the lower level in 30 minutes.

number = ____________________

(2)

(Total 10 marks)

12 A constant resultant horizontal force of 1.8×10^3 N acts on a car of mass 900 kg, initially at rest on a level road.

(a) Calculate

(i) the acceleration of the car,

____

____

(ii) the speed of the car after 8.0 s,

____

____

(iii) the momentum of the car after 8.0 s,

____

____

(iv) the distance travelled by the car in the first 8.0 s of its motion,

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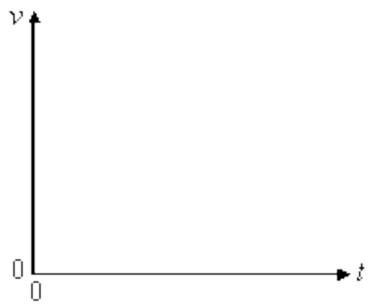
____

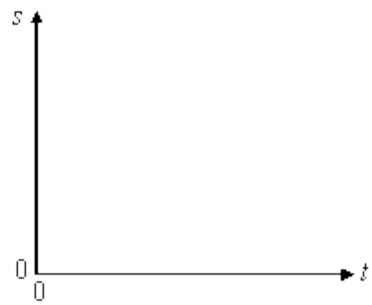
____

(v) the work done by the resultant horizontal force during the first 8.0 s.

(9)

(b) On the axes below sketch the graphs for speed, *v*, and distance travelled, *s*, against time, *t*, for the first 8.0 s of the car's motion.





(2)

(c) In practice the resultant force on the car changes with time. Air resistance is one factor that affects the resultant force acting on the vehicle.
You may be awarded marks for the quality of written communication in your answer.

(i) Suggest, with a reason, how the resultant force on the car changes as its speed increases.

(ii) Explain, using Newton's laws of motion, why the vehicle has a maximum speed.

(5)

(Total 16 marks)