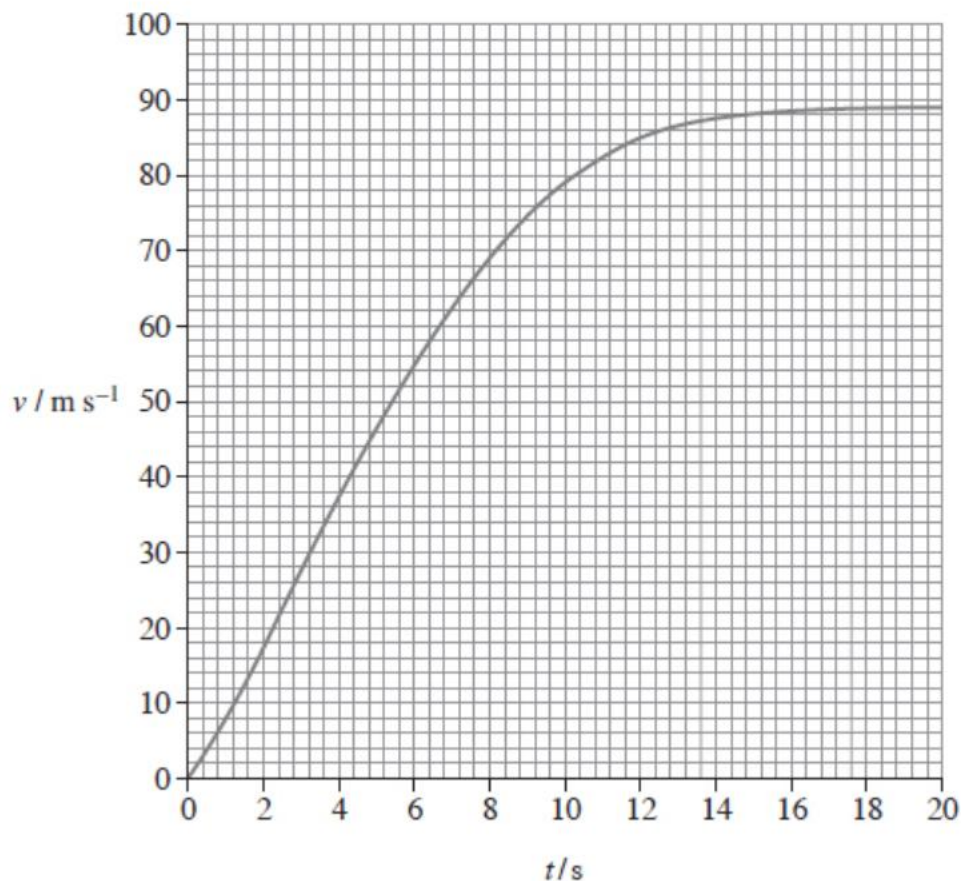


1

Figure 1 shows the variation of velocity v with time t for a Formula 1 car during a test drive along a straight, horizontal track.

The total mass of the car and driver is 640 kg. The car engine provides a constant driving force of 5800 N.

Figure 1



- (a) (i) Determine the distance travelled by the car during the first 10 s.

distance _____ m

(3)

- (ii) Show that the instantaneous acceleration is about 4 m s^{-2} when t is 10 s.

(2)

- (iii) Calculate the magnitude of the resistive forces on the car when t is 10 s.

resistive forces _____ N

(3)

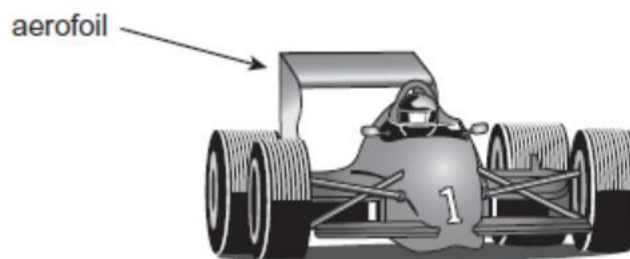
- (iv) Calculate the power, in kW, of the car at the maximum speed during the test drive.

power _____ kW

(2)

- (b) **Figure 2** shows the aerofoil that is fitted to a Formula 1 car to increase its speed around corners.

Figure 2



However, the aerofoil exerts an unwanted drag force on the car when it is travelling in a straight line so a Drag Reduction System (DRS) is fitted. This system enables the driver to change the angle of the aerofoil to reduce the drag.

The graph in **Figure 1** is for a test drive along a straight, horizontal track. Under the conditions for this test drive, the DRS was not in use and the engine produced a constant driving force.

Explain why the velocity varies in the way shown in the graph.

Go on to explain how the graph will be different when the DRS is in use and the driving force is the same.

The quality of written communication will be assessed in your answer.

(6)

(Total 16 marks)

2

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} .

(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.

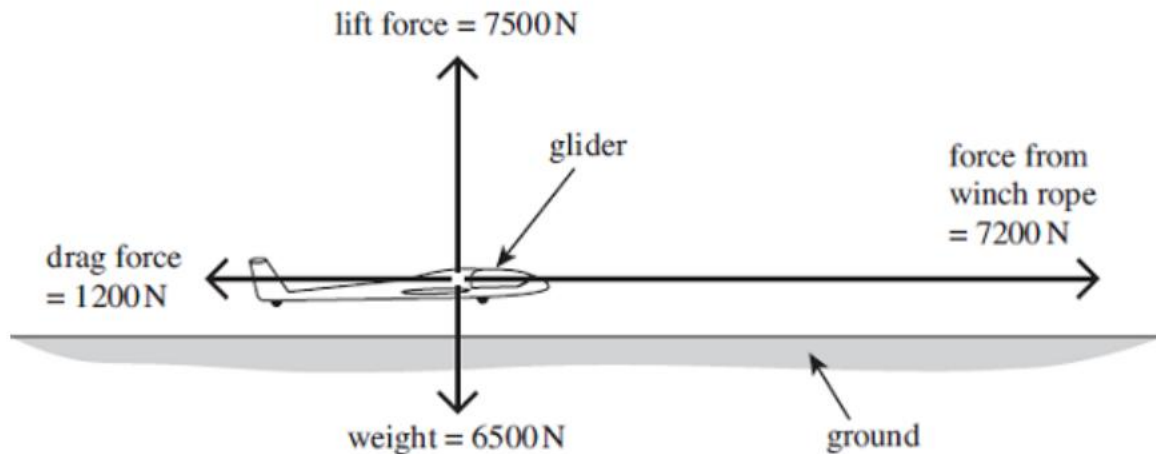
horizontal resistive force = _____ N

(2)

(Total 11 marks)

3

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)

4

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)

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

velocity = _____ ms^{-1}

(2)

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

time = _____ s

(2)

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

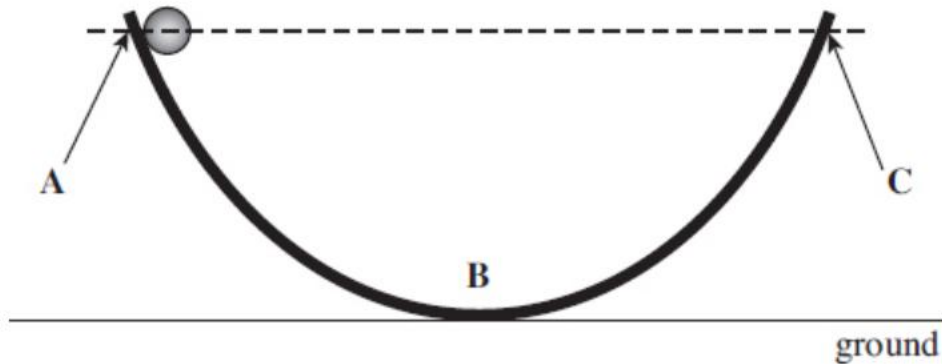
(3)

(Total 9 marks)

5

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



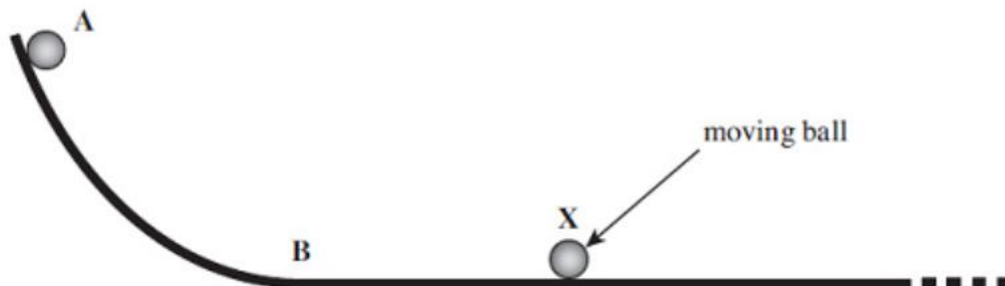
- (a) Galileo thought that, under these circumstances, the ball would reach position **C** if released from rest at position **A**. Position **C** is the same height above the ground as **A**.

Using ideas about energy, explain why Galileo was correct.

(3)

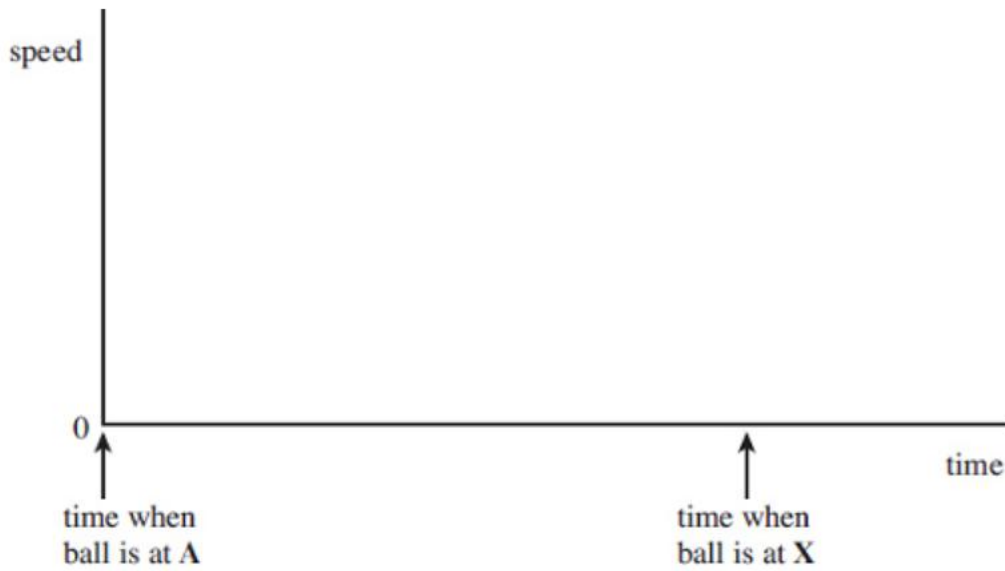
- (b) Galileo then imagined that the track was changed, as shown in **Figure 2**.

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.

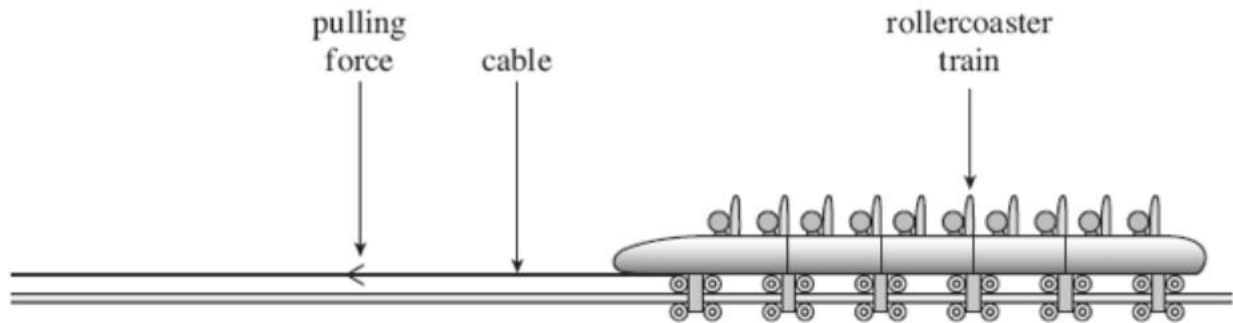
Explain how Newton's first law of motion is illustrated by the motion of the ball between **B** and **X**.

(2)

(Total 8 marks)

6

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}

(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.

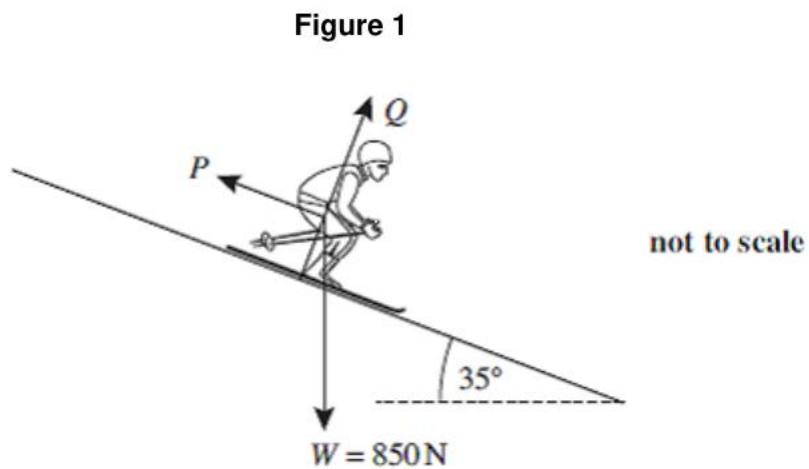
answer = _____ m

(3)

(Total 13 marks)

7

- (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.



- (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.

(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.

deceleration _____ ms^{-2}

(2)

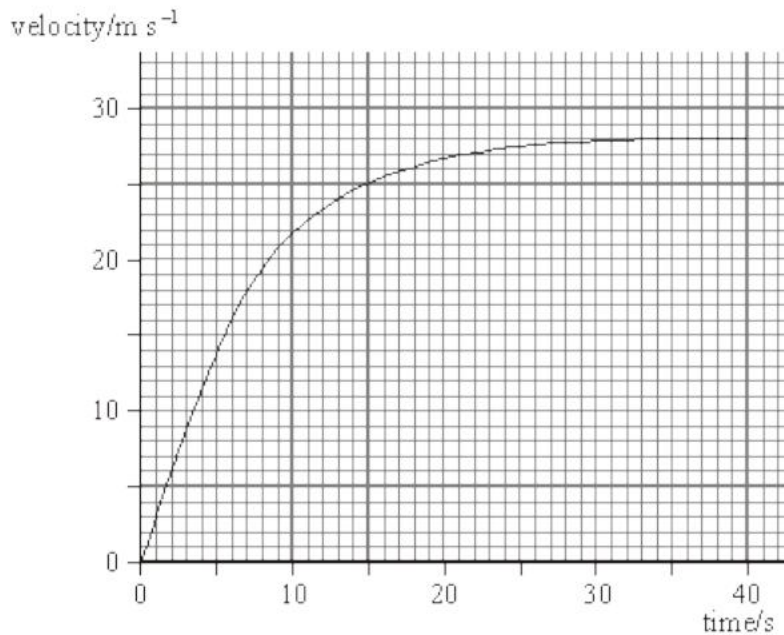
- (ii) State and explain what would happen to the deceleration as the skier continues along the level snow.

(2)

(Total 11 marks)

8

The figure below shows how the velocity of a motor car increases with time as it accelerates from rest along a straight horizontal road.



- (a) The acceleration is approximately constant for the first five seconds of the motion. Show that, over the first five seconds of the motion, the acceleration is approximately 2.7 m s^{-2} .
- (b) Throughout the motion shown in the figure above there is a constant driving force of 2.0 kN acting on the car.
- (i) Calculate the mass of the car and its contents

(3)

mass _____

- (ii) What is the magnitude of the resistive force acting on the car after 40 s?

resistive force _____

(3)

- (c) Find the distance travelled by the car during the first 40 s of the motion.

distance _____

(3)

(Total 9 marks)

9

A radio-controlled model car has a mass of 0.65 kg.

- (a) The car accelerates uniformly from rest to 3.5 m s^{-1} in 1.5 s. Calculate:

- (i) the acceleration of the car,

acceleration _____

- (ii) the resultant force acting on the car during this acceleration.

resultant force _____

(4)

- (b) After 1.5 s the motor is switched off and the car decelerates uniformly until it stops. The deceleration is 0.60 m s^{-2} .

- (i) Calculate the resistive force acting on the car.

resistive force _____

- (ii) Assuming that the resistive force was constant throughout the motion, calculate the thrust from the motor when the car was accelerating.

thrust _____

(2)

- (c) Calculate the **total** distance travelled by the car.

total distance travelled _____

(2)

(Total 8 marks)

10

An object of mass 3.2 kg is acted on by two forces which are at right angles to each other. The resultant force is 11.5 N.

- (a) Calculate the acceleration of the object.

(2)

- (b) One of the forces has a magnitude of 6.0 N.

Using a scale diagram or otherwise, find:

- (i) the magnitude of the other force;

(2)

- (ii) the angle between the resultant force and the 6.0 N force.

(2)

(Total 6 marks)

11

A horizontal force of 1.5 kN acts on a motor car of mass 850 kg that is initially at rest.

(a) Calculate:

(i) the acceleration of the motor car;

(1)

(ii) the speed of the motor car after 15 s;

(2)

(iii) the distance travelled by the motor car in the first 7.5 s of the motion;

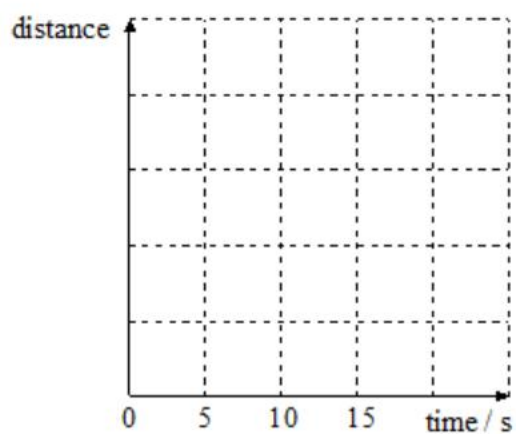
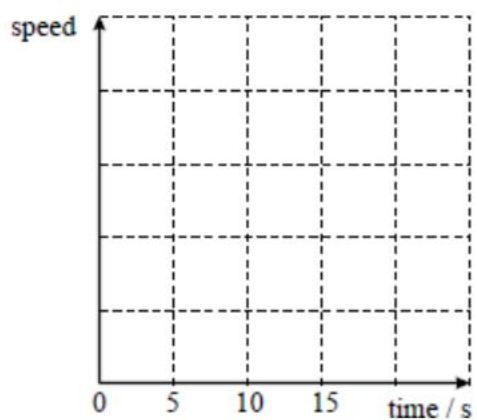
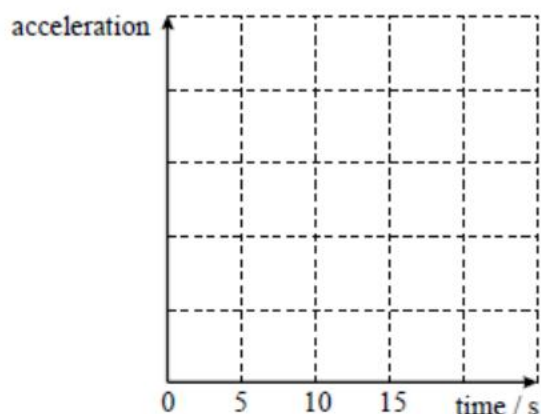
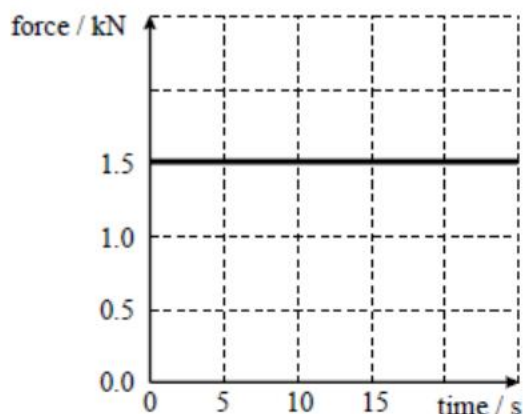
(2)

(iv) the distance travelled by the motor car in the first 15 s of the motion.

(1)

- (b) The diagrams below show the graph of force against time together with three incomplete sets of axes. Sketch on these axes the corresponding graphs for acceleration, speed and distance travelled for the first 15 seconds of the car's motion.

You should include labels for the axes and any known numerical values.



- (c) In practice the resultant force exerted on the motor car will not be constant with time as suggested by the force-time graph. Air resistance is one factor that affects the resultant force acting on the vehicle.

- (i) Suggest how the force-time graph will change when air resistance is taken into account. Explain your answer. You may wish to sketch a graph to illustrate your answer.

(3)

- (ii) Explain why the vehicle will eventually reach a maximum speed even though the motorist keeps the accelerator pedal fully depressed.

(2)

(Total 15 marks)

12

- (a) State the difference between vector and scalar quantities.

(1)

- (b) State **one** example of a vector quantity (other than force) and **one** example of a scalar quantity.

Vector quantity _____

(1)

Scalar quantity _____

(1)

- (c) A 6.0 N force and a 4.0 N force act on a body of mass 7.0 kg at the same time. Calculate the maximum and minimum accelerations that can be experienced by the body.

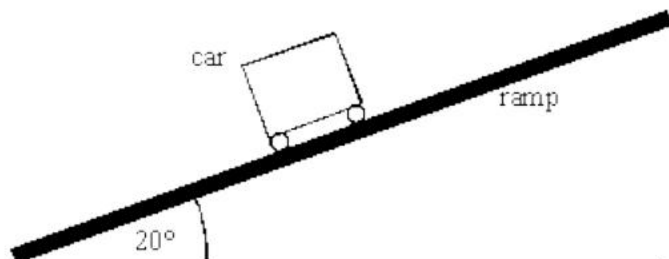
Maximum acceleration _____ Minimum acceleration _____

(3)

(Total 6 marks)

13

A fairground ride ends with the car moving up a ramp at a slope of 20° to the horizontal as shown in the diagram below.



- (a) The car carrying its maximum load of passengers has a total weight of 6.8 kN. Show that the component of the weight acting parallel to the ramp is about 2.3 kN.

(2)

- (b) The mass of the fully loaded car is 690 kg. Show that the force in part (a) will decelerate the car at about 3.3 m s^{-2} .

(2)

- (c) The car enters the ramp at 22 m s^{-1} . Calculate the minimum length that the ramp must be in order for the car to stop before it reaches the end. Neglect the length of the car.

Minimum length _____

(2)

- (d) The ride owner decides to use a shorter ramp and to install brakes on the car. The additional decelerating force provided by these brakes is 4600 N . Calculate the new stopping time.

Stopping time _____

(3)

(Total 9 marks)

14

Figure 1 shows a graph of velocity against time for an aircraft of mass 2.8×10^4 kg landing on a stationary aircraft-carrier.

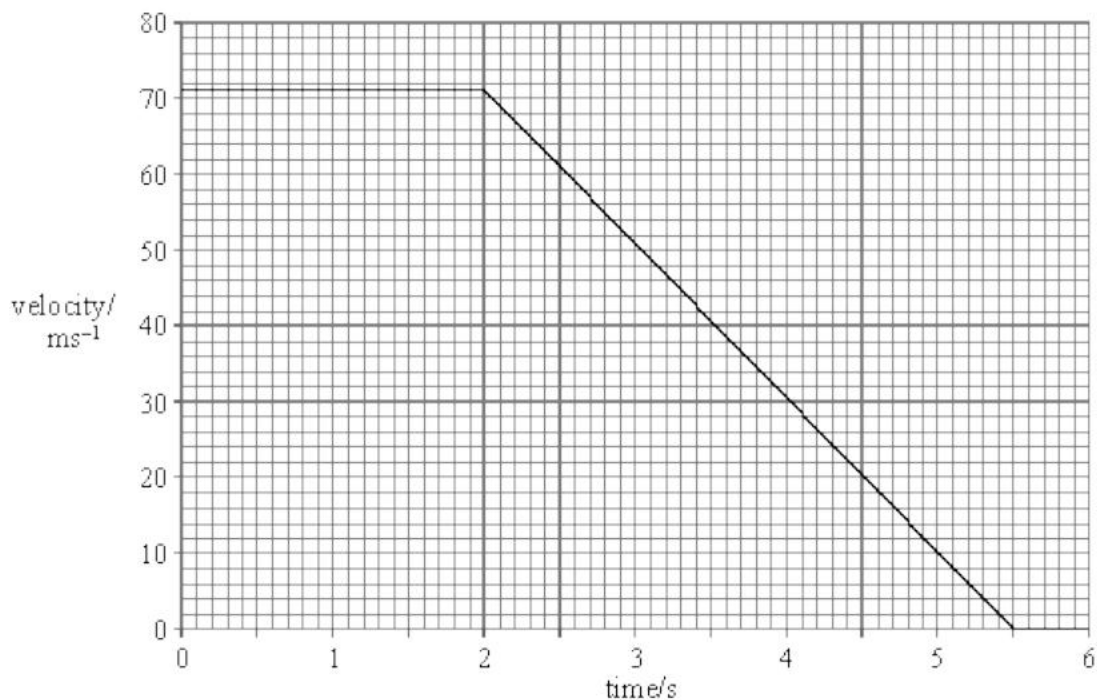


Figure 1

- (a) (i) Calculate the initial kinetic energy of the aircraft.

Initial kinetic energy _____

(2)

- (ii) Show that the deceleration of the aircraft is about 20 m s^{-2} .

(3)

- (iii) Calculate the decelerating force acting on the aircraft.

Force _____

(2)

- (b) A steam catapult is used to enable aircraft to take off from the ship. The catapult accelerates the aircraft from rest to its take-off speed of 71 m s^{-1} in a distance of 62 m.

Calculate the acceleration of the aircraft.

Acceleration _____

(2)

- (c) In level flight, the pilot sets the course to be 80 m s^{-1} due north. There is a wind blowing from east to west at 20 m s^{-1} . Find, by scale drawing or otherwise, the resultant velocity of the aircraft.

Velocity of aircraft: magnitude _____

direction _____

(3)

Mark schemes

1

- (a) (i) Attempt to determine area under curve
Number of "large" squares (22 ± 1)
or distance per square = 20 (large) or 0.8 (small)
 435 ± 10 (m)

Zero marks for use of suvat

3

- (ii) Tangent to curve seen drawn at 10 s
Gradient of tangent = 4.2 (allow 3.5 – 4.5) (m s^{-2})

Zero marks for use of suvat

2

- (iii) 640×4 or 2560 or $640 \times$ their 7aii
5800-2560 or 5800-($640 \times$ their 7aii)
3200 (3240) (N)

3

- (iv) 89 (read off from graph) cnao
520 (516) (kW)

If answer is in W, then unit must be given

2

- (b) The marking scheme for this question includes an overall assessment for the quality of written communication (QWC). There are no discrete marks for the assessment of QWC but the candidate's QWC in this answer will be one of the criteria used to assign a level and award the marks for this question.

Descriptor – an answer will be expected to meet most of the criteria in the level descriptor.

Level 3 – good

- claims supported by an appropriate range of evidence;
- good use of information or ideas about physics, going beyond those given in the question;
- argument is well structured with minimal repetition or irrelevant points;
- accurate and clear expression of ideas with only minor errors of grammar, punctuation and spelling.

Level 2 – modest

- claims partly supported by evidence;
- good use of information or ideas about physics given in the question but limited beyond this;
- the argument shows some attempt at structure;
- the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling.

Level 1 – limited

- valid points but not clearly linked to an argument structure;
- limited use of information about physics;
- unstructured;
- errors in spelling, punctuation and grammar or lack of fluency.

Level 0

- incorrect, inappropriate or no response.

Allow named resistive forces e.g. air resistance, drag, friction.

Allow thrust for driving force.

Explanation of velocity variation:

Car accelerates / Velocity increases because driving force is larger than resistive forces

Maximum acceleration at start

Resistive forces are zero at start

Resistive forces increase with increasing velocity

Drag proportional to velocity-squared

Resultant force decreases with increasing velocity

Acceleration decreases with increasing velocity

Terminal velocity reached when resultant force is zero / resistive forces balance the driving force

Explanation of change with DRS in use:

Resistive forces reduced (because air resistance / drag) is reduced

Resultant force is non-zero for longer time

Acceleration occurs over longer time

Terminal velocity reached in longer time

Higher terminal velocity achieved

Higher maximum velocity on graph
Same initial acceleration / gradient on graph

6

[16]

2

- (a) (i) $(a = (v - u) / t)$
 $= 27.8 (-0) / 4.6 = 6.04 \checkmark$
 $= \underline{6.0} \text{ (ms}^{-1}\text{)} \checkmark$
no need to see working for the mark
2 sig fig mark stands alone

2

- (ii) $(F = ma)$
 $= (360 + 82) \times 6.0(4) \checkmark$ (allow CE from (i))
 $= 2700 \text{ (N)} \checkmark$ (2670 N or 2652 N)
 $F = 442 \times (i)$
1 mark may be gained if mass of rider is ignored giving answer
2200N from 2175N

2

- (b) (forward force would have to) increase $\checkmark$
 air resistance / drag increases (with speed) $\checkmark$
driving / forward force must be greater than resistive / drag force $\checkmark$
no mark for wind resistance

(so that) resultant / net force stayed the same / otherwise the resultant / net force would decrease $\checkmark$

4max3

- (c) horizontal force arrows on both wheels towards the right starting where tyre meets road or on the axle labelled driving force or equivalent $\checkmark$
ignore the actual lengths of any arrows
ignore any arrows simply labelled 'friction'

a horizontal arrow to the left starting anywhere on the vehicle labelled drag / air resistance

no mark for wind resistance, resistance or friction force
the base of an arrow is where the force is applied

2

- (d) $(F = P / v)$
 $= 22\,000 / 55 \checkmark$ Condone 22 / 55 for this mark
 $= 400 \checkmark \text{ (N)}$

2

[11]

- (a) (i) 1000(N) AND 6000(N) seen

*Independent marks***OR**

$$F = \sqrt{(1000)^2 + (6000)^2} \quad \checkmark \text{ allow incorrect values seen}$$

$$= 6083 \text{ (N) } (= 6100) \quad \checkmark \text{ More than 2 sf seen}$$

*Allow full credit for appropriate scale drawing**Ignore rounding errors in 3rd sig fig.*

2

- (ii)
- $\tan \theta = 1000 / 6000$
- or correct use of sin or cos
- $\checkmark$

$$\theta = 9.5 \text{ (} 9.46^\circ \text{)} \quad \checkmark$$

Allow range 9.4 – 10.4

*Use of cos yields 10.4**Allow use of 6100**Some working required for 2 marks.**Max 1 mark for correct calculation of vertical angle (range 79.6 – 80.6) some working must be seen*

2

- (iii)
- $(m = W/g =) 6500 / 9.81 (= 662.6 \text{ kg}) \quad \checkmark$

$$(a = F / m = 6083 / 662.6)$$

$$= 9.2 \text{ (ms}^{-2}\text{)} \quad \checkmark \text{ (9.180)}$$

*Use of weight rather than mass gets zero**Correct answer on its own gets 2 marks**Penalise use of $g=10$ in this question part only (max 1)*

2

- (b) (i)
- $= 6500 \times 600 \quad \checkmark \text{ (} 662.6 \times 9.81 \times 600 \text{)}$

$$= 3\,900\,000 \quad \checkmark \text{ (J)}$$

*Look out for $W \times g \times h$ which gives 39000000 (gets zero)**Correct answer on its own gets 2 marks****Do not allow use of $1/2 mv^2 (= 39\,000)$***

2

- (ii)
- $(E = Pt =) 320\,000 \times 55 (= 17\,600 \text{ kJ})$

$$\text{OR } P = 1(b)(i) / 55 \text{ (} 7.09 \times 10^4 \text{)} \quad \checkmark$$

$$3.9 / 17.6 \text{ OR } 70.9 / 320 \text{ OR } = 0.22(16) \quad \checkmark \text{ ecf from first line}$$

*Some valid working required for 3 marks*conversion to a percentage $(= 22 \%) \quad \checkmark$ *Look out for physics error: Power / time (320/55) then use of inverted efficiency equation yielding correct answer**Do not allow percentages $\geq 100\%$ for third mark*

3

4

- (a) $(E_p = mg\Delta h)$
 $= 65 \times 9.81 \times 54$ ✓
 $= 3.44 \times 10^4 = 3.4 \times 10^4 \text{ (J)}$ ✓ (34433)
max 1 if $g = 10$ used (35100 J)
Correct answer gains both marks

2

- (b) $v = \sqrt{\frac{2E_p}{m}}$ OR $v = \sqrt{\frac{2 \times 34433}{65}}$ ✓ $= 33 \text{ (32.55 ms}^{-1}\text{)}$ ✓ ecf 1(a)
allow 32 (32.3) for the use of 34000
allow 32.6

OR correct use of $v^2 = 2gs$
don't penalise $g = 10$ (32.863)

2

- (c) $(s = 1/2 gt^2 \text{ or other kinematics equation})$
 $t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2 \times 54}{9.81}}$ ✓ $= 3.318 = 3.3 \text{ (s)}$ ✓

*With use of $g = 9.8$ or 9.81 or 10 and / or various suvat equations,
 expect range 3.2 to 3.4 s.
 No penalty for using $g = 10$ here.*

ecf from 1(b) if speed used

2

- (d) (all G)PE (lost) is transferred to KE
 no (GP)E transferred to 'heat' / 'thermal' / internal energy
OR ✓

Must imply that all GPE is transferred to KE. E.g. accept 'loss of GPE is gain in KE' but not: 'loses GPE and gains KE'.

(therefore) $mg\Delta h = \frac{1}{2}mv^2$ ✓
 mass cancels. ✓

Accept 'm's crossed out

3

[9]

5

- (a) *GPE to KE to GPE* ✓

no energy lost (from system) / no work done against resistive forces ✓

initial GPE = final (GPE) / initial (GPE) = final GPE

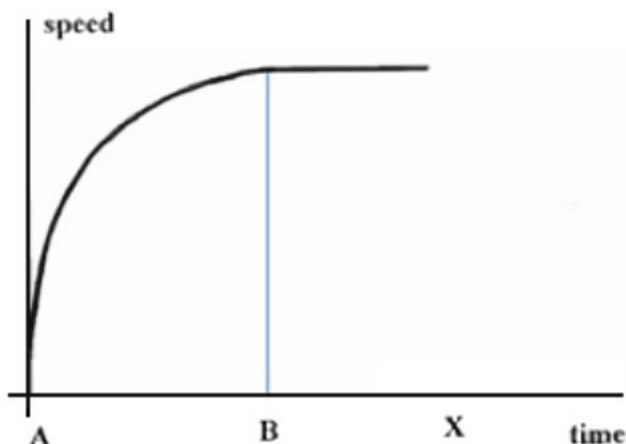
OR $h = GPE/mg$ and these are all constant so h is the same ✓

3

- (b) Initial curve with decreasing gradient and reaching constant maximum speed before X and maintaining constant speed up to X ✓

B labelled in correct place ✓

B labelled in correct place **AND** constant speed maintained for remainder of candidates graph and line is straight ✓



3

- (c) (first law) ball travels in a straight line at a constant speed / constant velocity / (maintains) uniform / no change in motion / zero acceleration ✓

there is no (external) **unbalanced** / **resultant** force acting on it ✓

2

[8]

6

(a) (i) $(a = \frac{v-u}{t}) = \frac{58}{3.5} \checkmark = 17 \text{ (m s}^{-2}\text{)} \checkmark$

2

(ii) $(F = ma) = 5800 \times 16.57 \text{ ecf (a)(i)} \checkmark$
 $= 96000 \checkmark$

allow 98600 or 99000 for use of 17

N ✓

3

(iii) $(s = \frac{1}{2}(u+v)t) = \frac{1}{2} \times 58 \times 3.5 \checkmark$

$= 100 \text{ (101.50, 102, accept 101 m)} \checkmark$

or use of $v^2 = u^2 + 2as$ (= 101 m. 98.9 for use of 17) 2

or $s = ut + \frac{1}{2}at^2$ (= 101.7, use of 17 gives 104) (ecf from (a)(i))

2

(iv) ($W = Fs$) (a)(ii) $\times$ (a)(iii) or use of $\frac{1}{2} mv^2$ ✓ (= 13.6 to 14.7)

$$\left(P = \frac{Fs}{t} \right) = \frac{96106 \times 101.5}{3.5} \checkmark = 2.8\text{M (W) ecf (a)(ii), (a)(iii)}$$

or use of $P = \frac{Fv}{2}$ their answer $\times 5$ ✓ = 14,000,000 = 14 M (W)

3

(b) $\frac{1}{2} (m) v^2 = (m) g (\Delta) h$ or (loss of) KE = (gain in) PE ✓

allow their work done from (iv) used as KE

$$h = \frac{1}{2} \frac{v^2}{g} \text{ or } h = \frac{1}{2} \times \frac{58^2}{9.81} \checkmark$$

accept use of kinematics equation

$$= 170 \checkmark$$

3

[13]

7

(a) (i) air resistance/drag

B1

(normal) reaction (of the ground on the skier)

B1

2

(ii) no resultant force (in any direction)/forces in equilibrium

B1

1

- (b) any closed triangle with W as a complete side

M1

closed triangle with correct lengths or angles even if P and Q are reserved

A1

correct triangle by eye

A1

force correct 490 ± 20 N

B1

4

- (c) (i) appropriate force/87 **ecf**

C1

5.4 to 5.9 ms^{-2} **cao**

A1

2

- (ii) deceleration would decrease

B1

resistance forces increase with speed/are
proportional to speed²/

resultant force gets smaller as speed gets less

B1

2

[11]

8

- (a) clear statement that gradient = acceleration *accept* $\Delta v/\Delta t$
or statement of $v = u + at$

B1

suitable values taken from graph

M1

3

i.e. (5.0, $13.5 - 0.5$) (4.0, $11 - 0.5$) (3.0, $8 - 0.5$)

acceleration = $2.7 - 0.1 \text{ (m s}^{-2}\text{)}$

(b) (i) *use of* $m = F/a$

C1

mass = 740 kg

accept 741 kg

or answer consistent with part (a)

A1

3

(ii) resistive force = 2.0 kN

c.a.o.

B1

(c) clear attempt to count squares/estimate area ($37 - 2 \text{ cm}^2$)

C1

scale factor $1 \text{ cm}^2:25 \text{ m}$

C1

3

distance = $925 - 50 \text{ m}$

rA1

[9]

9

(a) (i) $3.5/1.5 =$

C1

$$2.33 \text{ ms}^{-2}$$

A1

(ii) $F = ma$

C1

$$F = 1.52/1.50 \text{ N}$$

A1

4

(b) (i) $(0.65 \times 0.60) = 0.39 \text{ N}$

B1

(ii) $(1.52 + 0.39) = 1.91 \text{ N}$

allow ecf from (a) (ii) and/or (b) (i)

B1

2

(c) $0.5 \times 3.5 \times 1.5$

or $0.5 \times 3.5 \times (3.5/0.60)$

C1

$$(d = 2.63 + 10.21) = 12.8 \text{ m}$$

A1

2

[8]

10

(a) $F = ma$ (or correct equation with numbers)

C1

$$3.6 \text{ m s}^{-2}$$

A1

(2)

(b) (i) correct sketch of forces or attempt to apply pythagoras' theorem correctly

C1

$$9.8 \text{ N } (\pm 0.1 \text{ N for scale diagram})$$

A1

- (ii) $\cos(\text{angle}) = 6.0 / 11.5$
(allow correct alternative equation with e.c.f.)

C1

(correct angle measured for scale diagram)
 $58.5^\circ, 58.6^\circ$ or 59° (c.a.o.)
(58° to 59° for scale diagram)

A1

(2)

[6]

11

- (a) (i) (acceleration = F / m) 1.76 m s^{-2}

B1

(1)

- (ii) $(v = u + at) = 0 + 1.76 \times 15$

C1

$= 26.4 \text{ m s}^{-1}$
 allow e.c.f. from (i)

A1

(2)

- (iii) $(s = ut + 0.5 at^2) = 0.5 \times 1.76 \times 7.5^2$

C1

$= 49.5 \text{ m}$
 allow e.c.f. from (i)

A1

(2)

- (iv) t doubles so s quadruples $= 4 \times 49.5 \sim 200 \text{ m}$
 [or equivalent]

B1

(1)

- (b) acceleration graph correct: same shape as $F-t$;
 1.8 (1.76) identifiable on axis

B1

speed graph correct: straight line through origin to
 identifiable 26 m s^{-1}
 at 15 s

B1

distance graph correct: shape parabolic; both calculated points
 identifiably marked

B1

all axes labelled with unit

B1

(4)

- (c) (i) total force decreases as time increases [or appropriate graph]

B1

(because) speed increase leads to drag force increase

B1

total thrust is sum of engine force – drag (frictional force)

B1

(3)

- (ii) forward thrust = friction force

B1

so (total thrust = 0) and acceleration = 0

B1

(2)

[15]

12

- (a) vector has direction, scalar has no direction /
only vector has direction

B1

- (b) vector: any vector except force (accept weight)

B1

scalar: any scalar

B1

- (c) $F = ma$ in any form

C1

maximum: 1.4 m s^{-2}

minimum: 0.29 m s^{-2}

A1

[6]

13

- (a) $6800 \times \sin 20$

B1

= 2330 N

B1

2

- (b) $a = F/m$

B1

= $2300/690$ or $2300 = 690 \times a$

B1

2

(c) $v^2 = u^2 + 2as$

C1

$s = [22 \times 22/2/3.33] = 72.7 \text{ m}$ [73.3 if using 3.3 m;
71.8 possible]

A1

2

(d) $F = 6900$

C1

$a = F/m = [9.99/10]$

C1

$t = 22/99.9 \text{ or } 22/10 \text{ s } [= 2.2]$

A1

3

[9]

14

(a) (i) $\frac{1}{2} mv^2 = \frac{1}{2} \times 2.8 \times 10^4 \times 71^2$

C1

$$= 7.1 \times 10^7 \text{ J}$$

A1

2

(ii) decel = gradient of graph or $a = (v-u)/t$ or $\Delta v/\Delta t$ or evidence on graph

B1

$$= (71-0)/(3.5 - 0)$$

B1

$$= 20.3 \text{ [m s}^{-2}\text{]}$$

B1

3

(iii) $[F=ma] = 2.8 \times 10^4 \times 20.3$

C1

$$= 568 \text{ kN}$$

A1

2

(b) $v^2 = u^2 + 2as$
 $a = v^2/2s = 71^2/124$ or alt process
 $= 41 \text{ m s}^{-2}$ [40.6]

C1 A1

2

(c) drawing correct, scale clearly stated, wind speed
 line >+ 2 cm **or** one

B1

correct calculation

speed 82/83/82.5 m s⁻¹ [80 – 84 if drawn]

B1

course 14° [12 – 16] west of north [346°]

B1

3