1)

(a) Define a *vector quantity*.

....

.... **[1]**

(b) Circle all the vector quantities in the list below.

acceleration speed time displacement weight **[1]**

(c) Fig. 1.1 shows graphs of velocity v against time t for two cars **A** and **B** travelling along a straight level road in the same direction.

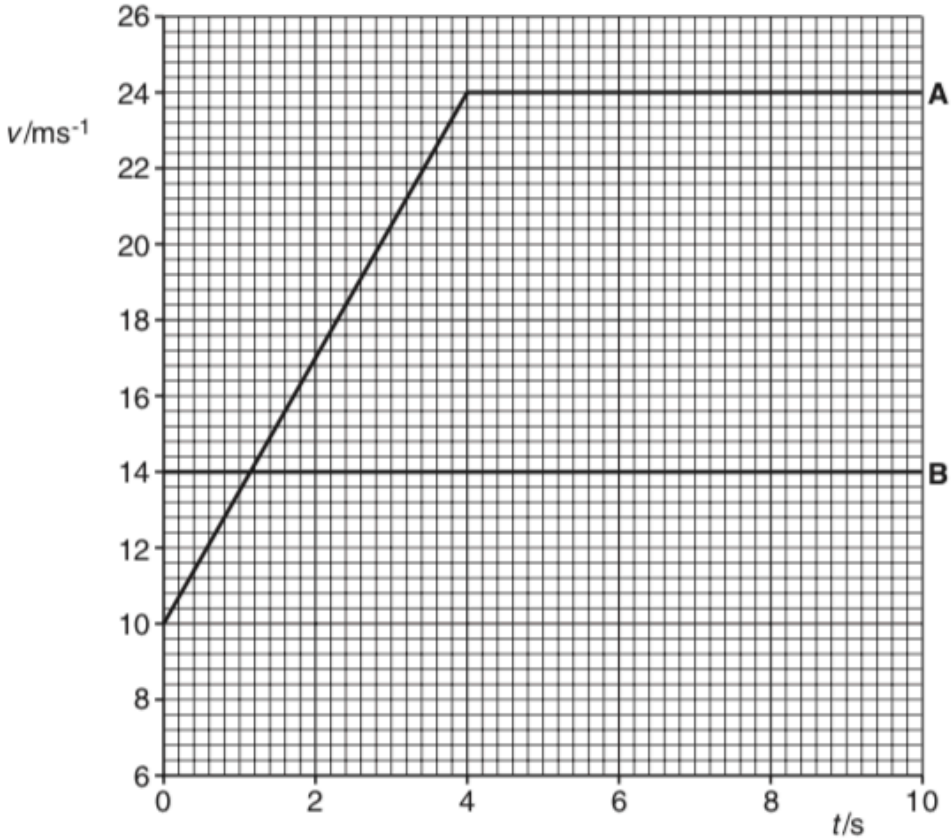

Fig. 1.1

At time $t = 0$, both cars are side-by-side.

(i) Describe the motion of car **A** from $t = 0$ to $t = 10$ s.

....

....

.... **[2]**

(ii) Calculate the distance travelled by car **A** in the first 4.0 s.

distance = ... m **[2]**

(iii) Use Fig. 1.1 to find

1 the time at which both cars have the same velocity

time = ... s **[1]**

2 the time *t* at which car **A** overtakes car **B**.

t = ... s **[2]**

[Total: 9]

2)

(a) Define *acceleration*.

....

.... **[1]**

(b) A super-tanker cruising at an initial velocity of 6.0 m s^{-1} takes 40 minutes (2400 s) to come to a stop. The super-tanker has a constant deceleration.

(i) Calculate the magnitude of the deceleration.

deceleration = ... m s^{-2} **[3]**

(ii) Calculate the distance travelled in the 40 minutes it takes the tanker to stop.

distance = ... m **[2]**

(iii) On Fig. 1.1, sketch a graph to show the variation of distance x travelled by the super-tanker with time t as it decelerates to a stop.

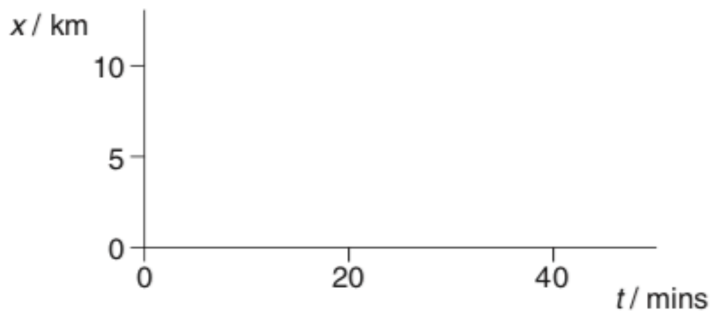

Fig. 1.1 **[2]**

(c) A student repeats one of Galileo's classic experiments from the sixteenth century. Fig. 1.2 shows the arrangement of this experiment.

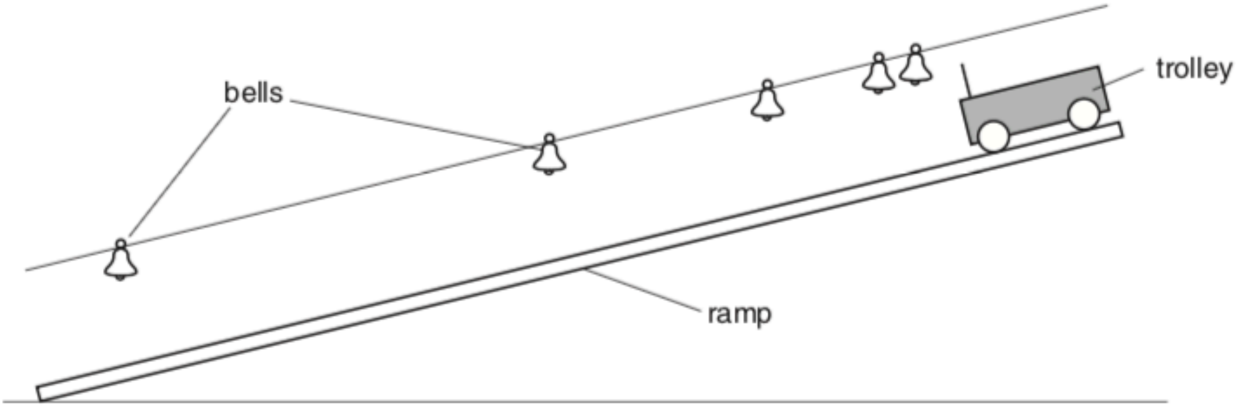

Fig. 1.2

A number of tiny bells are hung above a ramp. A trolley is released from rest from the top of the ramp. It rings each bell on its journey down the ramp. The procedure is repeated several times. The separations between the bells are adjusted until the time taken by the trolley to travel between successive bells is the **same**. This means that the bells ring at regular intervals. The distance between successive bells increases down the ramp.

(i) State what you can deduce about the motion of the trolley as it travels down the ramp.

....

.... **[1]**

(ii) The positions of the bells are unchanged. The mass of the trolley is increased. This heavier trolley is released from rest from the top of the ramp. State and explain the observations made by the student for this trolley.

....

....

....

....

.... **[2]**

[Total: 11]

3)

The terminal velocity of a raindrop falling vertically through air is 4.0 m s^{-1}.

(i) In terms of the forces acting on the raindrop, explain why it is at terminal velocity.

....

....

.... **[2]**

(ii) Fig. 1.2 shows a velocity vector diagram for the falling raindrop in a horizontal crosswind of speed 1.5 m s^{-1}.

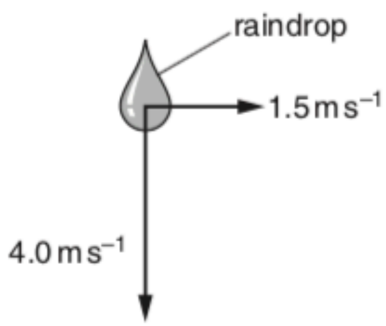

Fig. 1.2

1 On Fig. 1.2, draw an arrow on the raindrop to show the **direction** in which it will travel.

2 Calculate the magnitude of the resultant velocity of the raindrop. Use the space below for your working.

resultant velocity = ... m s^{-1} **[3]**

4)

Fig. 2.1 shows a graph of velocity against time for an object travelling in a straight line.

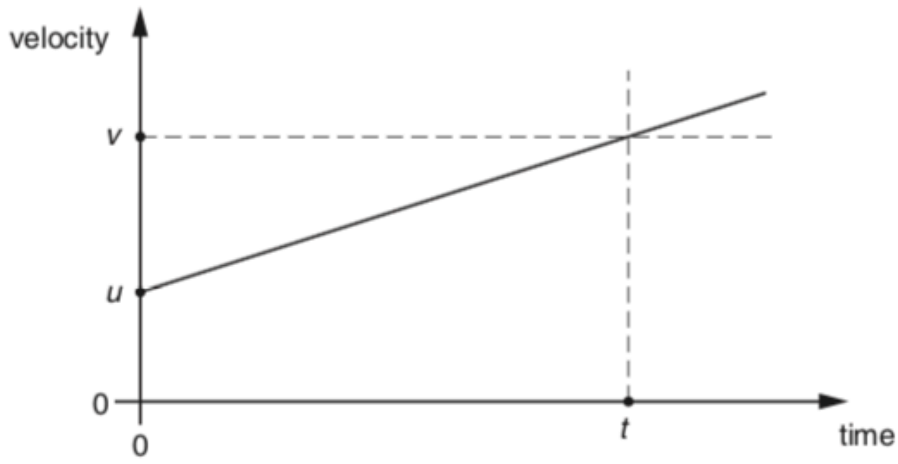

Fig. 2.1

The object has a constant acceleration *a*. In a time *t* its velocity increases from *u* to *v*.

(a) Describe how the graph of Fig. 2.1 can be used to determine

(i) the acceleration *a* of the object

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(ii) the displacement *s* of the object.

....

.... **[1]**

(b) Use the graph of Fig. 2.1 to show that the displacement s of the object is given by the equation:

$$s = ut + \frac{1}{2}at^2$$

[2]

(c) In order to estimate the acceleration g of free fall, a student drops a large stone from a tall building. The height of the building is known to be 32 m. Using a stopwatch, the time taken for the stone to fall to the ground is 2.8 s.

(i) Use this information to determine the acceleration of free fall.

acceleration = ... $m\,s^{-2}$ **[2]**

(ii) One possible reason why your answer to **(c)(i)** is smaller than the accepted value of $9.81\,m\,s^{-2}$ is the reaction time of the student. State another reason why the answer is smaller than $9.81\,m\,s^{-2}$.

....

.... **[1]**

[Total: 7]

5)

The terminal velocity of a raindrop falling vertically through air is 4.0 m s^{-1}.

(i) In terms of the forces acting on the raindrop, explain why it is at terminal velocity.

....

....

.... **[2]**

(ii) Fig. 1.2 shows a velocity vector diagram for the falling raindrop in a horizontal crosswind of speed 1.5 m s^{-1}.

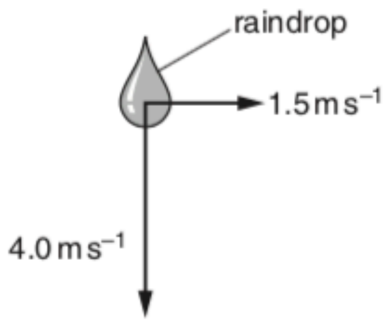

Fig. 1.2

1 On Fig. 1.2, draw an arrow on the raindrop to show the **direction** in which it will travel.

2 Calculate the magnitude of the resultant velocity of the raindrop. Use the space below for your working.

resultant velocity = ... m s^{-1} **[3]**

6)

(a) Fig. 3.1 shows the path taken by an aircraft as it flies from **A** to **B**.

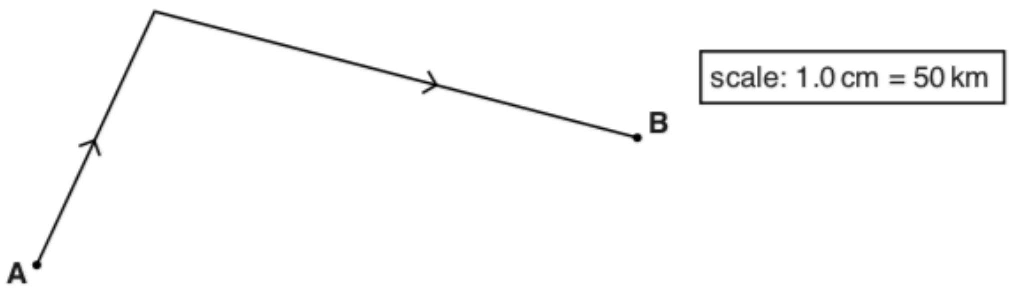

Fig. 3.1

On Fig. 3.1, a distance of 1.0 cm represents a distance of 50 km travelled by the aircraft. The aircraft takes 25 minutes to travel from **A** to **B**.

(i) Use Fig. 3.1 to determine the magnitude of the average velocity of the aircraft as it travels from **A** to **B**.

average velocity = ... $m\,s^{-1}$ **[3]**

(ii) Without doing any calculations, explain why the average speed of the aircraft is not the same as the magnitude of its average velocity.

....

....

.... **[1]**

(b) Io is one of the many moons of Jupiter. It travels at constant speed around Jupiter in a circular orbit of radius 4.2×10^8 m. Io takes 1.5×10^5 s to orbit once around Jupiter.

(i) Calculate the speed of Io in its orbit.

speed = ... $m s^{-1}$ **[2]**

(ii) Io has several active volcanoes on its surface. One of these volcanoes produces jets of sulphur with a velocity of $1.3 km s^{-1}$ that rise to 470 km above the volcano.

Calculate the constant acceleration of free fall on the surface of Io.

acceleration = ... $m s^{-2}$ **[3]**

7)

(a) Define *acceleration*.

....

.... **[1]**

(b) Explain why acceleration is a vector quantity.

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(c) Fig. 1.1 shows the graph of velocity v against time t for a moving object.

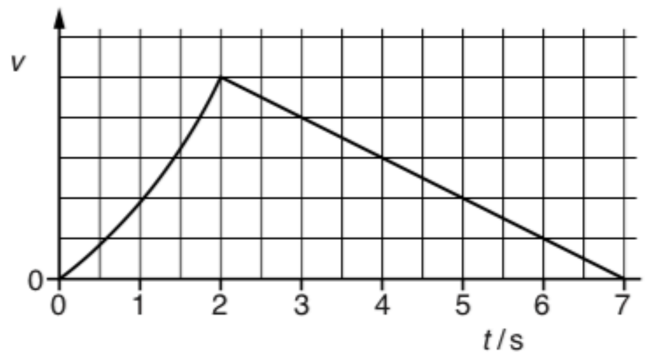

Fig. 1.1

(i) Describe the motion of the object from

1 $t = 0$ to $t = 2$ s

....

.... **[1]**

2 $t = 2$ s to $t = 7$ s.

....

.... **[1]**

(ii) Explain how Fig. 1.1 shows that the distance travelled by the object from $t = 0$ to $t = 2$ s is **shorter** than the distance travelled from $t = 2$ s to $t = 7$ s.

....

....

.... **[1]**

(d) The ventricle is one of two chambers in the heart that collects and expels blood. The left ventricle of the heart expels blood around the body. It accelerates blood from rest to a velocity of 0.26 m s^{-1}. The distance travelled by the blood during this acceleration is 0.020 m.

Assuming that the blood is accelerated uniformly, calculate the time taken for this acceleration.

time = ... s **[2]**

8)

Fig. 3.1 shows a rider on a sledge sliding down an icy slope.

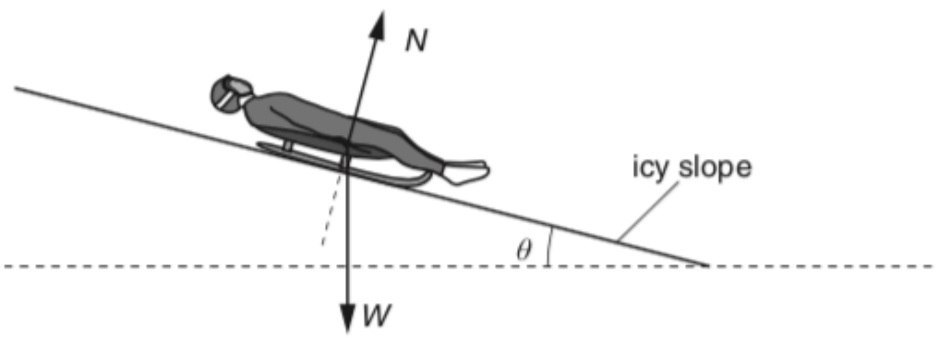

Fig. 3.1

The frictional forces acting on the sledge and the rider are negligible. The normal contact force *N* and the total weight *W* of the sledge and rider are shown.

Fig. 3.2 shows the velocity against time graph for the sledge and rider in **(c)** sliding down the icy slope.

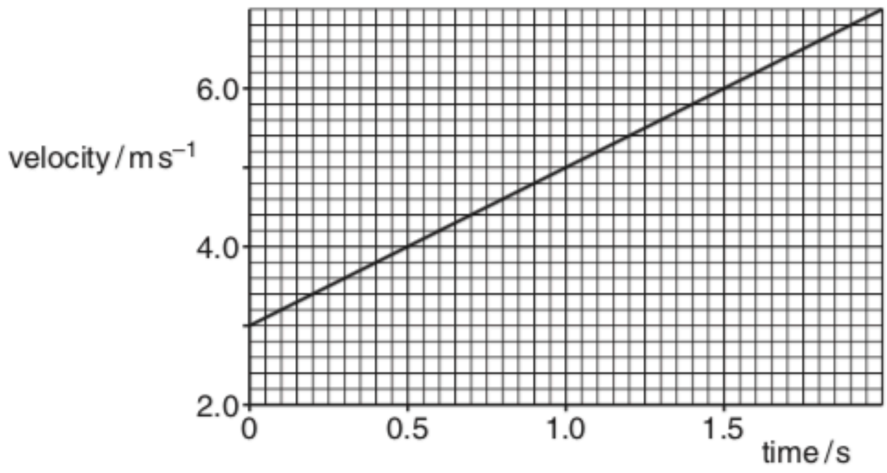

Fig. 3.2

(i) Use Fig. 3.2 to determine

1 the acceleration of the sledge and rider down the slope

acceleration = ... m s^{-2} **[2]**

2 the angle made by the slope to the horizontal.

angle = ... ° **[2]**

(ii) The sledge crashes into a foam barrier at the bottom of the slope.

The velocity of the sledge just before the impact is $15\,m\,s^{-1}$. The sledge and rider take 3.5 s to stop. The average decelerating force on the sledge and rider is 510 N.

Calculate the total mass of the sledge and rider.

mass = ... kg **[3]**

9)

(a) Speed is a scalar quantity and velocity is a vector quantity. State one difference and one similarity between speed and velocity.

difference: ....

....

similarity: ....

.... **[2]**

(b) Fig. 2.1 shows a toy locomotive on a circular track.

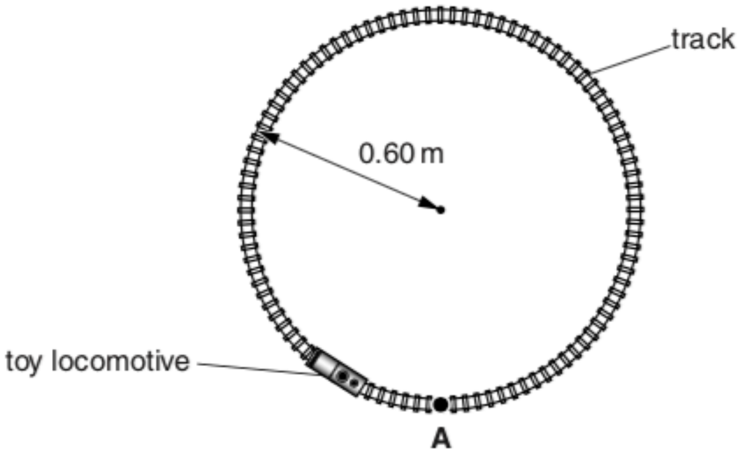

Fig. 2.1

The locomotive travels at constant speed round the track in a clockwise direction. It takes 12 s to travel completely round the track. At time $t = 0$, the locomotive is at point **A**.

(i) Calculate the speed of the locomotive.

speed = ... m s^{-1} **[2]**

(ii) Calculate the magnitude of the displacement s of the locomotive from point **A** after it has travelled one quarter of the way round the track.

s = ... m **[2]**

(iii) Explain why the average velocity of the locomotive is zero after a time of 12 s.

....

.... **[1]**

(iv) Explain why the velocity of the locomotive changes even though its speed is constant.

....

.... **[1]**

[Total: 8]

10)

Fig. 2.1 shows two masses **A** and **B** tied to the ends of a length of string. The string passes over a pulley. The mass **A** is held at rest on the floor.

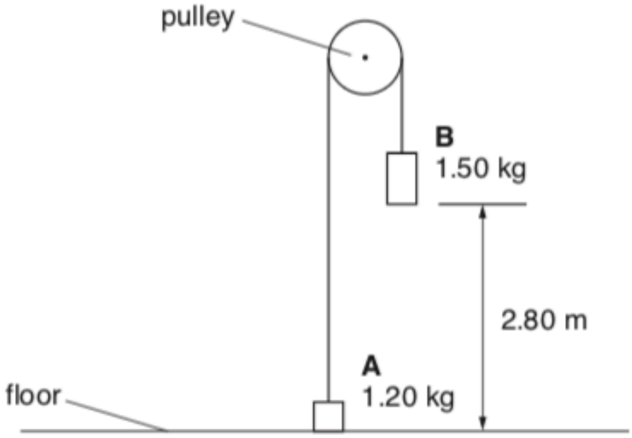

Fig. 2.1

The mass **A** is 1.20 kg and the mass **B** is 1.50 kg.

(a) Calculate the weight of mass **B**.

weight = ... N **[1]**

(b) Mass **B** is initially at rest at a height of 2.80 m above the floor. Mass **A** is then released. Mass **B** has a constant downward acceleration of 1.09 m s^{-2}. Assume that air resistance and the friction between the pulley and the string are negligible.

(i) In terms of forces, explain why the acceleration of the mass **B** is less than the acceleration of free fall *g*.

....

.... **[1]**

(ii) Calculate the time taken for the mass **B** to fall 1.40 m.

time = ... s **[3]**

(iii) Calculate the velocity of mass **B** after falling 1.40 m.

velocity = ... $m\,s^{-1}$ **[2]**

(iv) Mass **B** hits the floor at a speed of 2.47 $m\,s^{-1}$. It **rebounds** with a speed of 1.50 $m\,s^{-1}$. The time of contact with the floor is 3.0×10^{-2} s. Calculate the magnitude of the average acceleration of mass **B** during its impact with the floor.

acceleration = ... $m\,s^{-2}$ **[2]**

[Total: 9]

11)

(a) An electron in a particle accelerator experiences a constant force. According to one student, the acceleration of the electron should remain constant because the ratio of force to mass does not change. In reality, experiments show that the acceleration of the electron decreases as its velocity increases. Describe what can be deduced from such experiments about the nature of accelerated electrons.

....

....

....

.... **[2]**

(b) Fig. 4.1 shows the velocity vector for a particle moving at an angle of 31° to the horizontal.

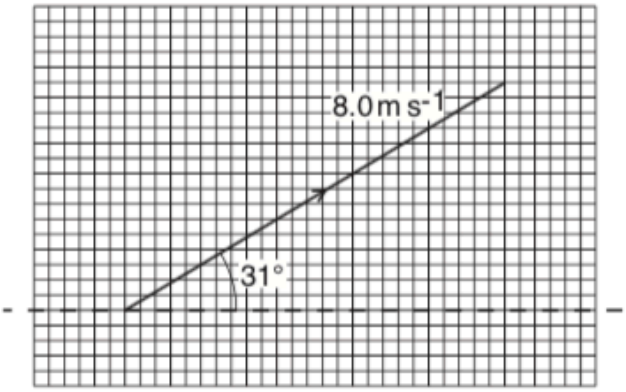

Fig. 4.1

(i) On Fig. 4.1, show the horizontal (*x*-direction) and vertical (*y*-direction) components of the velocity. **[2]**

(ii) Calculate the horizontal (*x*-direction) component of the velocity.

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