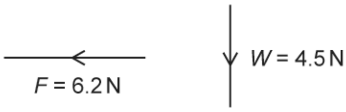
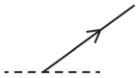
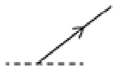
Nature of Quantities

1. An object is in equilibrium under the action of three coplanar forces *F*, *R* and *W*. The diagram below shows the forces *F* and *W*.



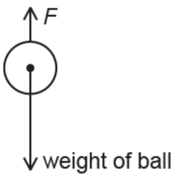
The angle between *F* and *W* is 90°.

Which row shows the correct magnitude of *R* and the approximate direction of *R*?

	Magnitude of *R* / N	Direction of *R*
A	7.7	
B	7.7	
C	10.7	
D	10.7	

Your answer **[1]**

2. A ball of mass m is falling vertically through the air.



The total upward force acting on the ball is *F*. The force *F* is less than the weight of the object.
The acceleration of free fall is *g*.

Which expression is correct for the acceleration *a* of the ball?

A $a = 0$

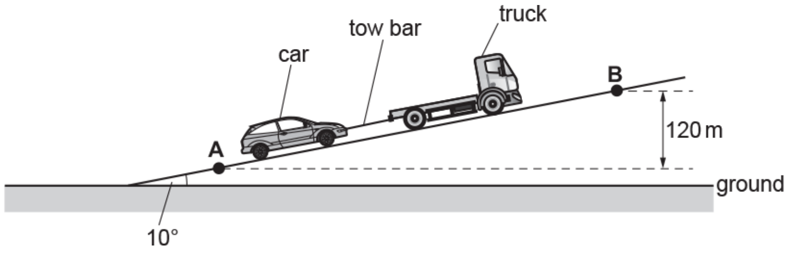
B $a = \frac{mg - F}{m}$

C $a = \frac{mg + F}{m}$

D $a = g$

Your answer **[1]**

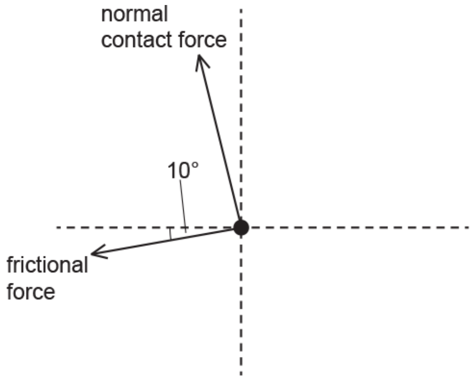
3 (a). A truck pulls a car up a slope at a **constant** speed.
The truck and the car are joined with a steel tow bar, as shown in the diagram.



The diagram is **not** drawn to scale.
The slope is 10° to the horizontal ground.
The mass of the car is 1100 kg.
The car travels from **A** to **B** . The vertical distance between **A** and **B** is 120 m.

There are four forces acting on the **car** travelling up the slope.

Complete the free-body diagram below for the car and label the missing forces.



[2]

(b). Show that the component of the weight of the car *W*s acting down the slope is about 1900 N.

[1]

(c). The total frictional force acting on the car as it travels up the slope is 300 N.

Calculate the force provided by the tow bar on the car.

force = ... N **[1]**

(d). Calculate the work done by the force provided by the tow bar as the car travels from **A** to **B** .

work done = ... J **[3]**

(e). The steel tow bar used to pull the car has length 0.50 m and diameter 1.2×10^{-2} m.
The Young modulus of steel is 2.0×10^{11} Pa.
The force on the tow bar is 2200 N.

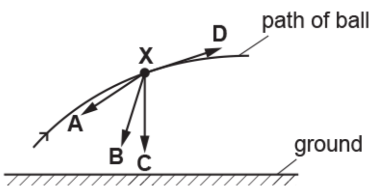
Calculate the extension *x* of the tow bar as the car travels up the slope.

x = ... m **[3]**

4. State what is meant by a *vector quantity* and give one example.

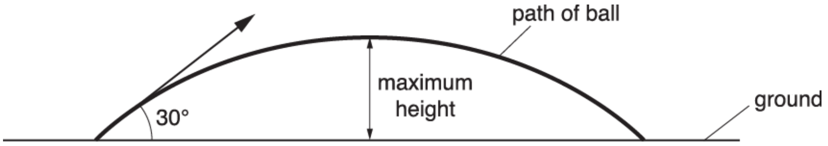
---**[1]**

5. A ball is thrown through the air. The ball experiences a small amount of drag compared to its weight.
At a particular time the ball is at point **X**.
Which arrow best represents the direction of the resultant force on the ball when it is at **X**?



Your answer [ ] **[1]**

6. A ball is thrown at an angle of 30° to the horizontal. The initial kinetic energy of the ball is *K*. Air resistance has negligible effect on the motion of the ball.



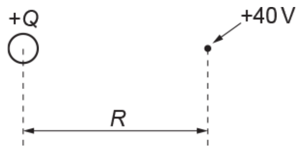
What is the kinetic energy of the ball at the maximum height?

A 0
B 0.25 *K*
C 0.75 *K*
D 0.87 *K*

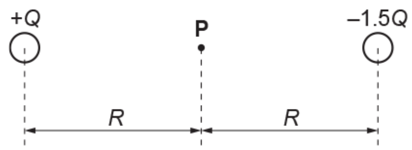
Your answer

[1]

7. The electric potential at a distance *R* from the centre of a charge +*Q* is + 40 V.



What is the potential at the point **P** for the arrangement of the charges +*Q* and −1.5*Q* as shown below?

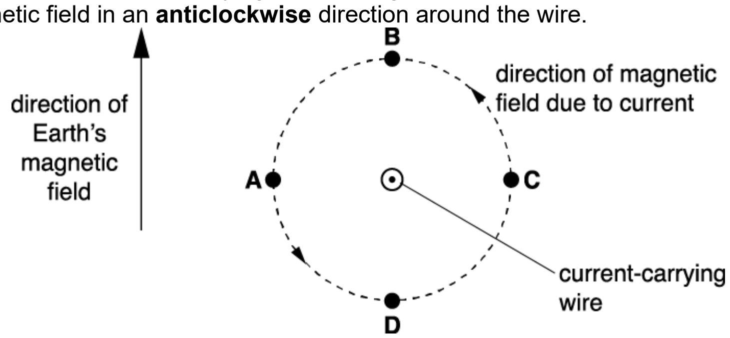


A − 20 V
B − 60 V
C + 80 V
D + 100 V

Your answer

[1]

8. The diagram below shows a current-carrying wire coming out from the plane of the paper. The current in the wire produces a magnetic field in an **anticlockwise** direction around the wire.



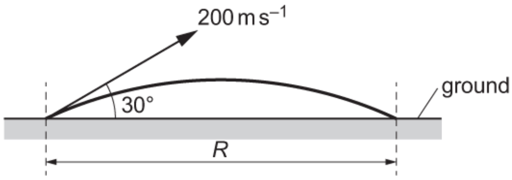
The direction of the Earth's magnetic field is also shown.
The Earth's magnetic field interacts with the magnetic field of the current-carrying wire.

At which point **A**, **B**, **C** or **D** is the resultant magnetic field strength a **minimum**?

Your answer

[1]

9. A bullet is fired at an angle of 30° to the horizontal ground at a velocity of 200 ms^{-1}.
The bullet is in flight for a time *t*.
Air resistance has negligible effect on the motion of the bullet.



What is the correct expression for the horizontal distance *R* travelled by the bullet?

A $R = 200 \times \cos30° \times t$

B $R = 200 \times \sin30° \times t$

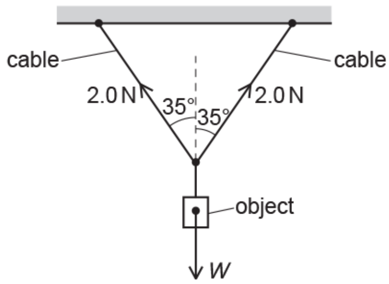
C $R = \dfrac{(200 \times \cos30°)^2}{2 \times 9.81}$

D $R = \dfrac{(200 \times \sin 30°)^2}{2 \times 9.81}$

Your answer **[1]**

10. An object of weight W is suspended from two identical cables.

The tension in each cable is 2.0 N. Each cable makes an angle of 35° to the vertical.



What is the weight *W* of the object?

A 1.6 N

B 2.3 N

C 2.8 N

D 3.3 N

Your answer **[1]**

11. The London Eye, shown rotating anticlockwise in **Fig. 6.1**, is a giant wheel which rotates slowly at a constant speed.

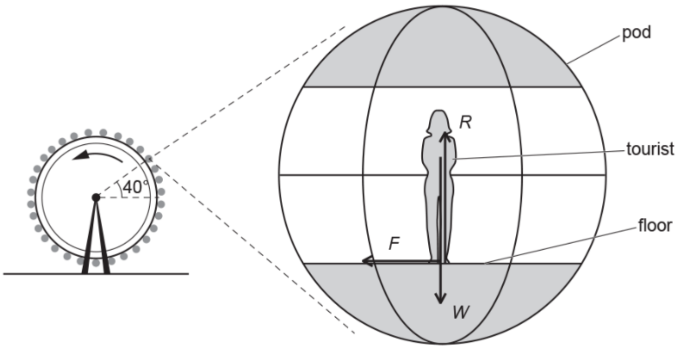


Fig. 6.1 **Fig. 6.2**

Tourists stand in pods around the circumference of the wheel.
The floor remains horizontal at all times.
At time t = 0, a tourist who has a weight W of 650 N enters a pod at the bottom of the wheel.
Fig. 6.2 shows the forces acting on the tourist at a later time, when the angle between the pod's position and the centre of the wheel is 40° above the horizontal. R is the normal contact force and F is friction.

The resultant upward force ($R - W$) on the tourist changes during the 30 minutes of the rotation of the London Eye as shown in **Fig. 6.3**.

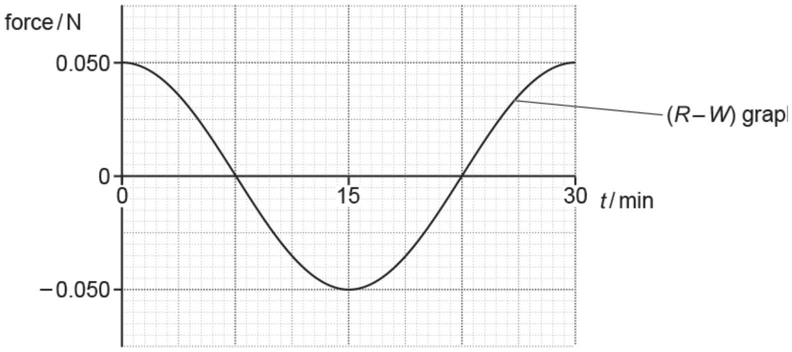


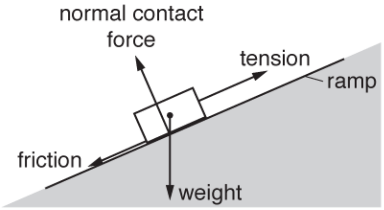
Fig. 6.3

Explain how the graph in **Fig. 6.3** shows that the magnitude of the centripetal force on the tourist during the rotation is 0.050 N.

[1]

12. A block moves at **constant** speed up a ramp.

The diagram below shows all the forces acting on the block.



Which force does no work on, or against, the object as it travels up the ramp?

A weight

B friction

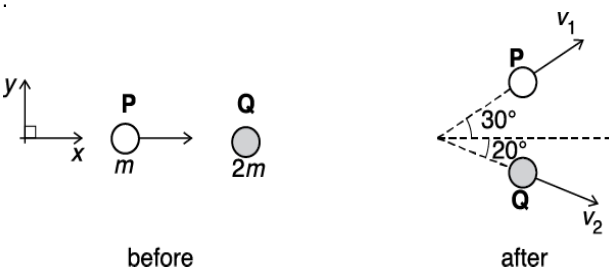
C tension

D normal contact force

Your answer

[1]

13. A ball **P** of mass m has a velocity in the positive x-direction. It makes a collision with a stationary ball **Q** of mass $2m$. After the collision, the ball **P** has velocity v_1, ball **Q** has velocity v_2 and the balls travel in the directions shown in the diagram below.



After the collision, the total momentum of the balls in the x-direction is p_x and the total momentum in the y-direction is p_y.

Which row is correct for p_x and p_y?

	p_x	p_y
A	$2mv_2 \cos 20° + mv_1 \cos 30°$	0
B	$2mv_2 \sin 20° + mv_1 \sin 30°$	0
C	$2mv_2 \cos 20° + mv_1 \cos 30°$	$2mv_2 \sin 30° + mv_1 \sin 20°$
D	$2mv_2 \sin 20° + mv_1 \sin 30°$	$2mv_2 \cos 30° + mv_1 \cos 20°$

Your answer

[1]

14. Which set of quantities are all scalar?

A acceleration, displacement, velocity
B energy, mass, power
C extension, force, gravitational potential energy
D weight, kinetic energy, work done

Your answer

[1]

15. An object experiences two forces, 3.0 N and 4.0 N, in the same plane. The directions of the forces are not known.

What is the magnitude of the resultant force *F* acting on the object?

A $F = 5.0$ N

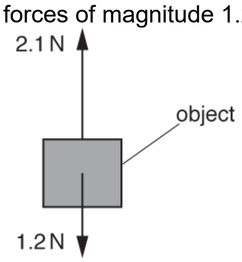
B $F = 7.0$ N

C $1.0\text{ N} \leq F \leq 7.0\text{ N}$

D $4.0\text{ N} \leq F \leq 7.0\text{ N}$

Your answer [1]

16. The diagram shows two opposite vertical forces of magnitude 1.2 N and 2.1 N acting on an object.



Which of the following statements could be correct?

1 The object is accelerating and moving up.

2 The object is decelerating and moving down.

3 The magnitude of the resultant force is 0.9 N.

A Only 3

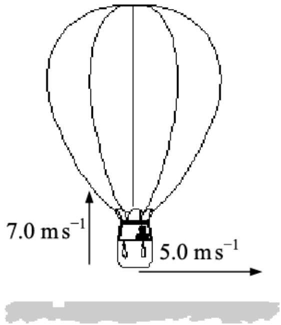
B Only 1 and 3

C Only 2 and 3

D 1, 2 and 3

Your answer [1]

17. When a sandbag is dropped from a balloon hovering 1.3 m above the ground, it hits the ground at 5.0 ms^{-1}. On another occasion, the sandbag is released from the balloon which is rising at 7.0 ms^{-1} when 1.3 m above the ground. There is also a crosswind of 5.0 m s^{-1}.



At what speed does the sandbag hit the ground?

A. 2.0 ms^{-1}
B. 5.4 ms^{-1}
C. 10 ms^{-1}
D. 13 ms^{-1}

Your answer

[1]

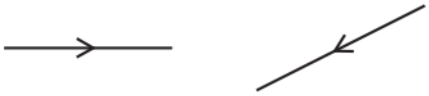
18. An object is falling.
The weight of the object is 4.5 N.
The wind provides a horizontal force of magnitude *F* on the object.
The **resultant** force on the object is 5.8 N.
Air resistance and upthrust on the object are negligible.

What is the value of *F*?

A 1.3 N
B 3.7 N
C 7.3 N
D 13 N

Your answer **[1]**

19. Two forces act in the plane of this paper.
The magnitude and direction of the two forces are shown below.



The two forces are added together.

Which diagram shows the correct resultant?

A 

B 

C 

D 

Your answer ☐ **[1]**

20 (a). Fig. 22 shows two identical springs supporting an object.

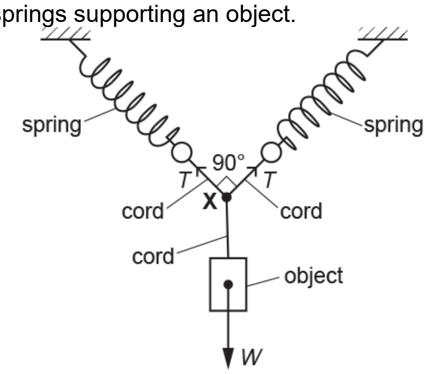


Fig. 22

Three short lengths of cord are tied together at point **X**. The other ends of the cords are attached to the ends of the springs and the object as shown in Fig. 22. The angle between the central axes of the springs is 90°.
The tension in each spring is the same and equal to *T*. The weight *W* of the object is 4.8 N.
The point **X** is in equilibrium.

Show that the tension *T* in each extended spring is 3.4 N.

[2]

(b). The force constant of each spring is 24 N m^{-1}.
Calculate the energy stored in each spring.

energy = J **[2]**

21 (a). Fig. 2.1 shows the path of a golf ball which is struck at point **F** on the fairway landing at point **G** on the green. The effect of air resistance is negligible.

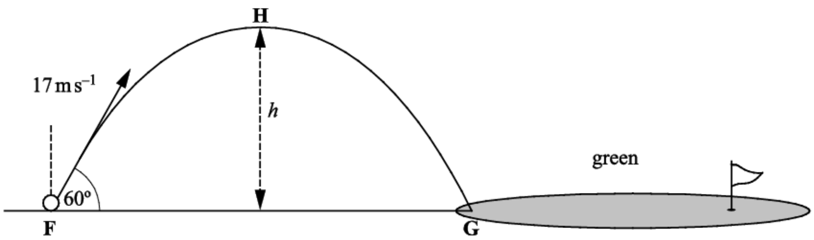


Fig. 2.1

The ball leaves the club at 17 m s^{-1} at an angle of 60° to the horizontal at time $t = 0$.

At $t = 1.5$ s the ball reaches point **H**. Calculate

i. the maximum height h of the ball

h = ... m **[3]**

ii. the distance between the points **F** and **G**.

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

(b). Suppose the same golfer standing at **F** had hit the ball with the same speed but at an angle of 30° to the horizontal. See **Fig. 2.2**.

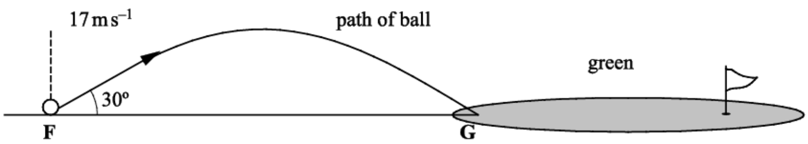


Fig. 2.2

Show that the ball would still land at **G**.

[3]

(c). Compare the magnitude and direction of the two velocities as the ball lands at G and using this information suggest, with a reason, which trajectory you would choose to travel a longer distance after hitting the green at G.

[2]

(d). Show that the speed of the ball at the highest point **H** of the trajectory is between 8 and 9 m s^{-1}.

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

22. Fig. 22 shows two identical springs supporting an object.

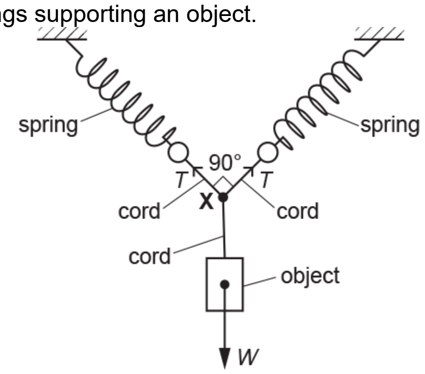


Fig. 22

Three short lengths of cord are tied together at point **X**. The other ends of the cords are attached to the ends of the springs and the object as shown in Fig. 22. The angle between the central axes of the springs is 90°.
The tension in each spring is the same and equal to *T*. The weight *W* of the object is 4.8 N.
The point **X** is in equilibrium.

State and explain the magnitude and the direction of the resultant force at **X** due to the two forces exerted by the extended springs.

[2]

23. Physical quantities can be added together. Velocity and mass are examples of two different types of physical quantities.
Discuss how the addition of two velocities differs from the addition of two masses.

[2]

24. A trolley is placed on a long ramp and is released from rest from the top of the ramp. It travels to the bottom of the ramp with a constant acceleration.

A motion sensor is used to determine the velocity of the trolley at points **X** and **Y**, as shown in Fig. 21.

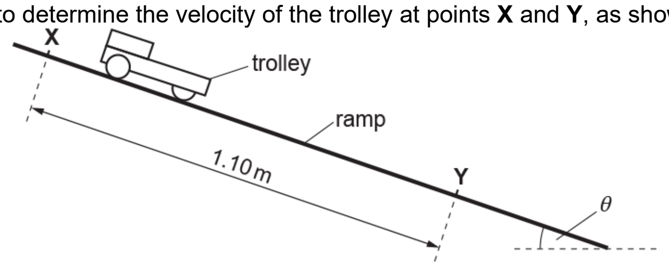


Fig. 21 (not to scale)

The distance between **X** and **Y** is 1.10 m. The trolley has velocity 1.3 ms^{-1} at **X** and velocity 2.5 ms^{-1} at **Y**.

i. Calculate the acceleration *a* of the trolley.

a = m s^{-2} **[2]**

ii. The frictional forces acting on the trolley are negligible.
The acceleration of the trolley down the ramp is equal to the component of the acceleration of free fall parallel to the ramp.
Use your answer to **(i)** to calculate the angle θ between the ramp and the horizontal.

θ = ° **[2]**

25. Fig. 1.1 shows a sign hanging from a rod fixed to a vertical wall. A metal wire attached between the rod and the wall holds the rod horizontal.

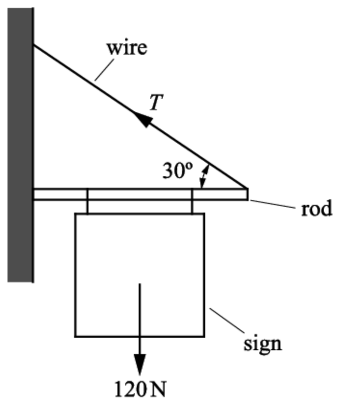


Fig.1.1

The weight *W* of the sign and rod act through the centre point of the rod. The value *W* is 120 N. The angle between wire and rod is 30°.

Calculate the tension *T* in the wire.

T = ... N **[2]**

26 (a). A cyclist moves along a horizontal road. She pushes on the pedals with a constant power of 250 W. The mass of the cyclist and bicycle is 85 kg. The total drag force is $0.4v^2$, where v is the speed of the cyclist.

The cyclist now moves up a slope at a constant speed of 6.0 ms^{-1} and continues to exert a power of 250 W on the pedals.

Fig. 17.1 represents the cyclist and bicycle as a single point **P** on the slope.

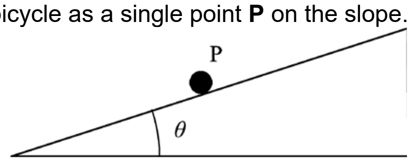


Fig. 17.1

i. Draw arrows on **Fig. 17.1** to represent the forces acting on **P**. Label each arrow with the force it represents.

[1]

ii. Calculate the angle *θ* of the slope to the horizontal.

θ = ... ° **[2]**

(b). The cyclist continues to move up the slope at 6.0 ms^{-1} and approaches a gap of width 2.5 m as shown in **Fig. 17.2**.

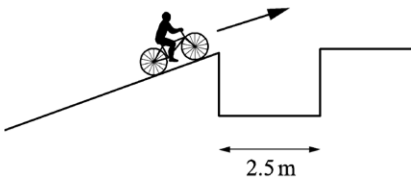


Fig. 17.2

A student has calculated that the cyclist will be able to clear the gap and land on the other side. Another student suggests that this calculation has assumed there is **no** drag and has not accounted for the effect caused by the front wheel losing contact with the slope before the rear wheel.

Without calculation, discuss how drag and the front wheel losing contact with the slope will affect the motion and explain how these might affect the size of the gap that can be crossed successfully.

[4]

27. An object is placed on a smooth horizontal surface. Two horizontal forces act on this object. **Fig. 21.3** shows the magnitudes and the directions of these two forces.

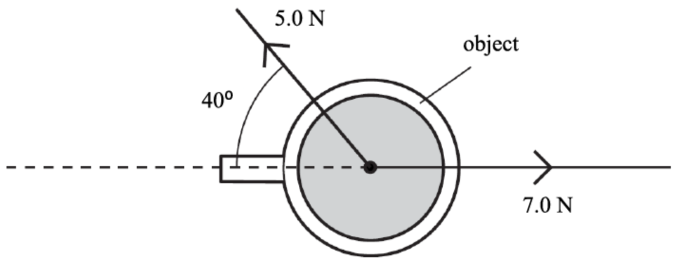


Fig. 21.3

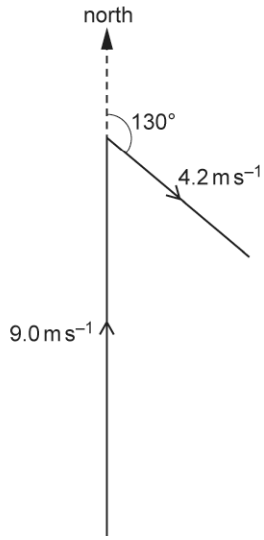
The mass of the object is 320 g.

Calculate the magnitude of the acceleration of the object.

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

28. A drone is travelling horizontally in a cross-wind.
The drone is travelling due north at a constant speed 9.0 m s^{-1} relative to the air.
The speed of the wind is 4.2 m s^{-1}. The direction of the wind is 130° from the north.

An incomplete vector diagram for determining the resultant velocity of the drone is shown below.



The vector diagram is drawn to scale.

i. Complete the vector diagram to show the resultant velocity of the drone.

[1]

ii. Determine the magnitude of the resultant velocity v of the drone.

v = ... ms^{-1} **[2]**

29. At an airport, the conveyor belt for suitcases moves at a constant speed of 1.5 m s^{-1}.
In Fig. 4.1, a suitcase of mass 8.0 kg has reached the line labelled **XX**'.

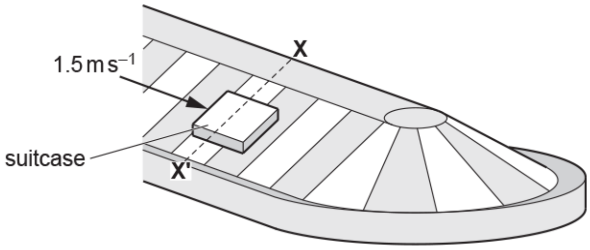


Fig. 4.1

Fig. 4.2 shows the situation in vertical cross-section. The frictional force *F* prevents the suitcase of weight *W* from sliding to the bottom of the belt.

The normal contact force on the suitcase is *R*.

The belt is inclined at an angle of 30° to the horizontal.

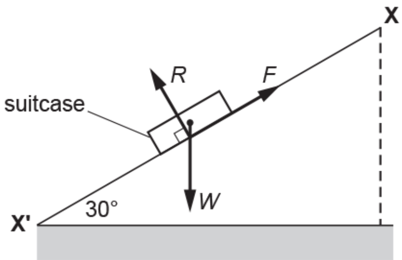


Fig. 4.2 (not to scale)

By using a vector triangle, or by resolving forces, calculate the magnitude of forces *F* and *R*.

F = ... N

R = ... N

[3]

30. Fig. 21.1 shows a toy locomotive on a circular track of radius 0.60 m.

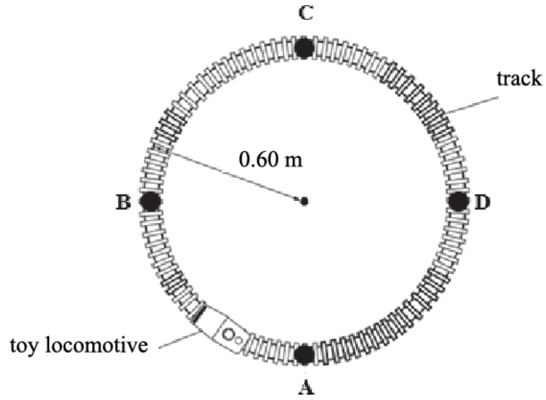


Fig. 21.1

At time t = 0, the locomotive is at point **A**. The locomotive travels at a constant speed round the track. It takes 20 s to travel completely round the track.

i. Calculate the speed of the locomotive.

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

ii. **Fig. 21.2** shows the variation of the magnitude of the displacement *s* of the locomotive from **A** with time *t.*

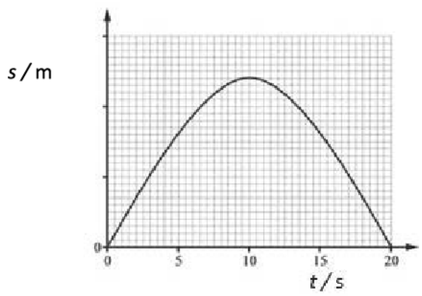


Fig. 21.2

Explain the graph shown in **Fig. 21.2**

[2]

31. In July 2018, the closest distance between the centre of Mars and the centre of Earth will be 5.8×10^{10} m. Fig. 17.3 shows the variation of the **resultant** gravitational field strength g between the two planets with distance r from the centre of the **Earth**.

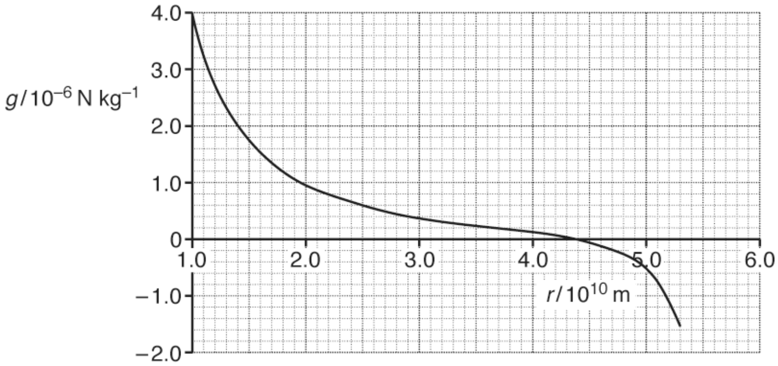


Fig. 17.3

i. Explain briefly the overall shape of the graph in Fig. 17.3.

[2]

ii. Use the value of r when $g = 0$ from Fig. 17.3 to determine the ratio $\frac{\text{mass of Earth}}{\text{mass of Mars}}$

$\frac{\text{mass of Earth}}{\text{mass of Mars}} =$ **[2]**

32. An engineer is investigating the tension in a steel cable supporting a uniform wooden plank as shown in Fig. 4.

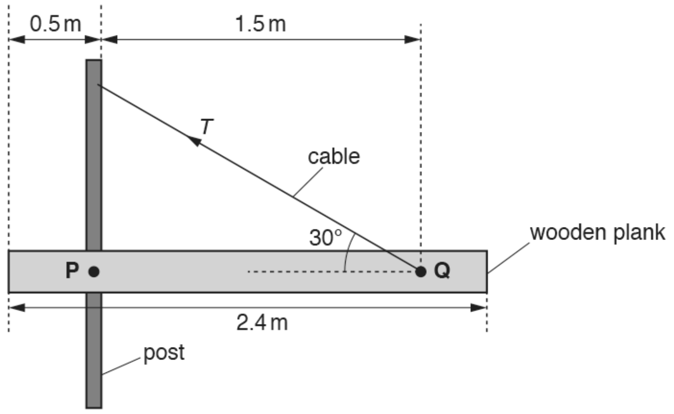


Fig. 4 (not to scale)

The plank is 2.4 m long and has a mass of 50 kg. It is pivoted at point **P** to a vertical post. The cable is fixed to the plank at point **Q** and to the vertical post as shown in Fig. 4. The cable is at an angle of 30° to the plank. The plank is in equilibrium and resting in a horizontal position.

Show that the tension *T* in the cable is about 460 N.

[4]

33. In a hockey match a hockey ball is hit 18.0 m from the front of the goal. The ball leaves the hockey stick with initial velocity *v* at an angle θ to the horizontal ground. The ball passes over the goal at a maximum height of 2.0 m as shown in Fig. 3.

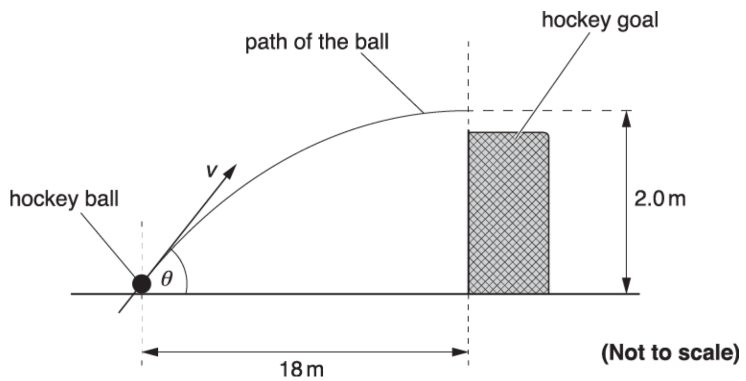


Fig. 3

The initial vertical component of the velocity of the ball is 6.3 m s^{-1}. Air resistance has negligible effect on the motion of the ball.

i. Show that the time *t* taken for the ball to reach the maximum height is about 0.6 s.

[1]

ii. Use the answer to **(i)** and **Fig. 3** to show that the horizontal component of the velocity of the ball as it leaves the hockey stick is about 30 m s^{-1}.

[1]

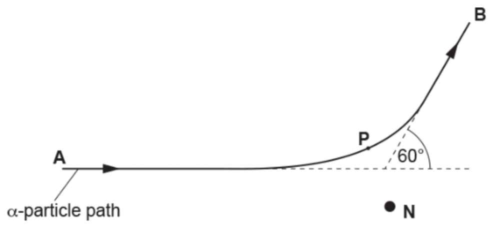
iii. Calculate the magnitude of the initial velocity *v* of the ball.

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

34. A beam of α-particles is incident on a thin gold foil. Most α-particles pass straight through the foil. A few are deflected by gold nuclei.

The diagram shows the path of one α-particle which passes close to a gold nucleus **N** in the foil. The α-particle is deflected through an angle of 60° as it travels from **A** to **B**.

P marks its position of closest approach to the gold nucleus.



The **magnitude** of the final momentum of the α-particle at **B** is equal to its initial value at **A**.

The gold nucleus **N** is initially at rest. During the passage of the α-particle from **A** to **B**, no other forces act on the two particles.

In the following questions label any relevant angles.

i. Draw two vectors in the spaces below to represent the initial momentum and the final momentum of the α-particle.

initial momentum at **A**

final momentum at **B**

[2]

ii. Draw a vector in the space below to represent the momentum of the nucleus **N** when the α-particle reaches **B**.

Explain how you determined this momentum.

[2]

35. Fig. 6.1 shows a uniform metal cylinder of weight 7.0 N. The cylinder has length 100 mm and diameter 32 mm.

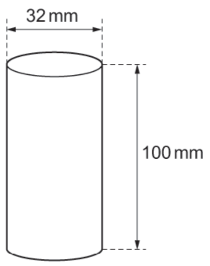


Fig. 6.1 (not to scale)

The cylinder is suspended by two cords **A** and **B**, attached to the centre of the top surface, as shown in **Fig. 6.2**.

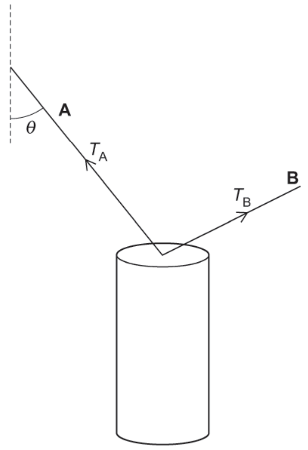


Fig. 6.2 (not to scale)

The tensions in each of the cords are T_A and T_B.

Fig. 6.3 shows T_B drawn to scale on graph paper.

Scale 1.0 cm represents 2.0 N.

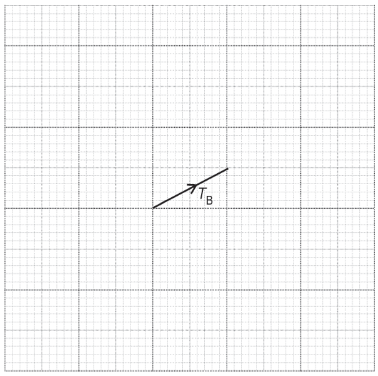


Fig. 6.3

i. Determine the magnitude of T_B.

T_B = ... N **[1]**

ii. Draw a triangle of forces on **Fig. 6.3** to represent the forces acting on the cylinder. Determine the magnitude of T_A.

T_A = ... N **[3]**

iii. Determine the angle θ in **Fig. 6. 2**.

θ = ... ° **[1]**

36 (a). Fig. 20.1 shows a positively charged metal sphere and a negatively charged metal plate.

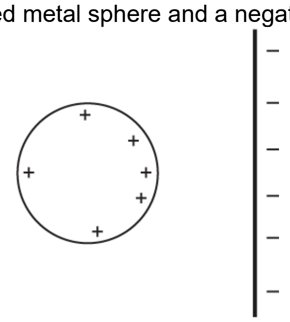


Fig. 20.1

On Fig. 20.1, draw a minimum of **five** electric field lines to show the field pattern between the sphere and the plate.

[2]

(b). Define *electric potential* at a point in space.

[1]

(c). A metal sphere is given a positive charge by connecting its surface briefly to the positive terminal of a power supply. The electric potential at the surface of the sphere is + 5.0 kV. The sphere has radius 1.5 cm.

i. Show that the charge Q on the surface of the sphere is 8.3×10^{-9} C.

[2]

ii. Fig. 20.2 shows the charged sphere from **(i)** suspended from a nylon thread and placed between two oppositely charged vertical plates.

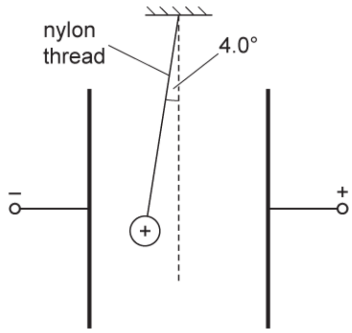


Fig. 20.2 (not to scale)

The weight of the sphere is 1.7×10^{-2} N. The string makes an angle of 4.0° with the vertical.

1. Show that the electric force on the charged sphere is 1.2×10^{-3} N.

[1]

2. Calculate the uniform electric field strength E between the parallel plates.

E = ... N C^{-1} **[2]**

37. Fig. 21.1 shows two oppositely charged ions to the left of a point **X**.

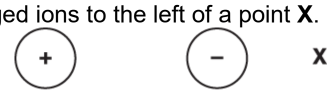


Fig. 21.1

The separation between the centres of the ions is 3.0×10^{-10} m. Each ion has charge of magnitude 1.6×10^{-19} C.

i. Explain why the direction of the **resultant** electric field strength at point **X** is to the left.

[2]

ii. Calculate the minimum energy in eV required to completely separate the ions.

energy = ... eV **[3]**

38. At an airport, the conveyor belt for suitcases moves at a constant speed of 1.5 m s^{-1}.
In Fig. 4.1, a suitcase of mass 8.0 kg has reached the line labelled **XX**'.

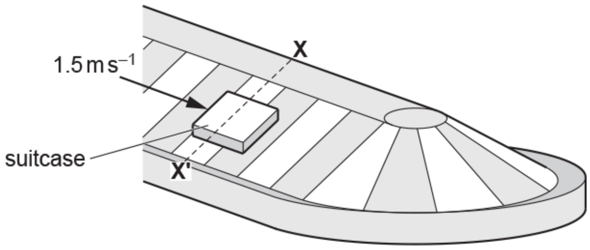


Fig. 4.1

Fig. 4.2 shows the situation in vertical cross-section. The frictional force *F* prevents the suitcase of weight *W* from sliding to the bottom of the belt.

The normal contact force on the suitcase is *R*.

The belt is inclined at an angle of 30° to the horizontal.

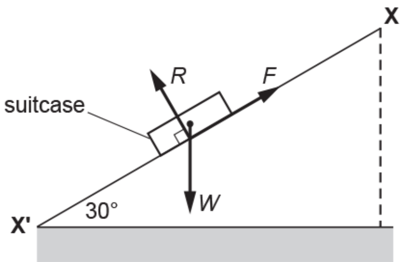


Fig. 4.2 (not to scale)

Fig. 4.3 shows the suitcase and the forces acting on it at the line labelled **YY'**.

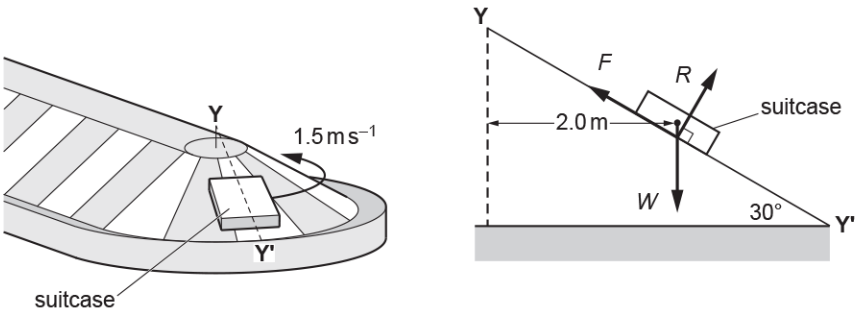


Fig. 4.3

The centre of mass of the suitcase is now moving at 1.5 m s^{-1} along a semi-circular arc of radius 2.0 m.

i. Calculate the magnitude of the centripetal force acting on the suitcase.

centripetal force = ... N **[2]**

ii. When the suitcase is at line **YY**', the magnitude of force *F* is larger and the magnitude of force *R* is smaller than at **XX**'.
Explain why this is so.

[4]

39. A metal ball is rolled off the edge of a horizontal laboratory bench. The initial horizontal velocity of the ball is v. The ball travels a horizontal distance x before it hits the level floor.

Use your knowledge of projectile motion to suggest the relationship between v and x. Describe how an experiment can be safely conducted to test this relationship and how the data can be analysed.

[6]

40. A linear air track is used to investigate the collision of two gliders **A** and **B**, as shown in **Fig. 3.1**.

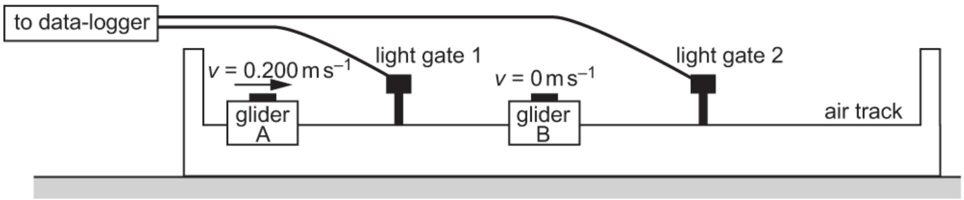


Fig. 3.1

Light gates 1 and 2 are connected to a data-logger to determine the speed of the gliders. Glider **A** has a mass of 0.75kg and glider **B** has a mass of 1.25 kg.

Two experiments are carried out.

Experiment 1

- Glider **B** is initially at rest between light gates 1 and 2.
- Glider **A** passes light gate 1 at a speed of 0.200 m s^{-1}.
- Glider **A** collides with glider **B**.
- Glider **A** rebounds and passes light gate 1 at a speed of 0.050ms^{-1} and glider **B** passes light gate 2 at a speed of 0.150 m s^{-1}.

Experiment 2

- Glider **B** is initially at rest between light gates 1 and 2.
- Glider **A** passes light gate 1 at a speed of 0.200 m s^{-1}.
- Glider **A** collides with glider **B**.
- Glider **A** sticks to glider **B**.
- Both gliders pass light gate 2 at a speed of 0.075 m s^{-1}.

With the help of calculations and the terms below, explain the results of the two experiments.

[6]

elastic	**inelastic**	**momentum**

41. A tennis ball is struck with a racket.
The initial velocity v of the ball leaving the racket is 30.0 m s^{-1} and it makes an angle of 70° to the horizontal as shown in Fig. 16.
Air resistance is negligible

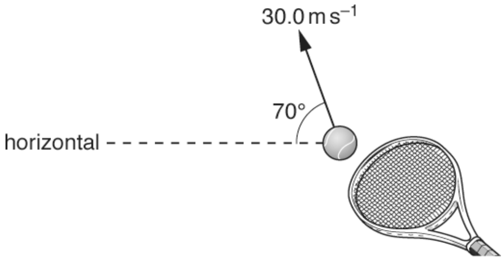


Fig. 16

i. Calculate the vertical component of the initial velocity of the ball.

vertical component = ________________ m s^{-1} **[1]**

ii. Use your answer in (**i**) to show that the ball reaches a maximum height *h* of about 40 m.

h = ________________ m **[2]**

iii. Explain why the kinetic energy of the ball is not zero at maximum height.

[1]

iv. The mass *m* of the ball is 57.0 g.
Calculate the kinetic energy E_k of the ball when it is at its maximum height.

E_k = J **[2]**

42. Fig. 21.2 shows a model dolphin in a museum. The dolphin is held in equilibrium by two cables **A** and **B**.

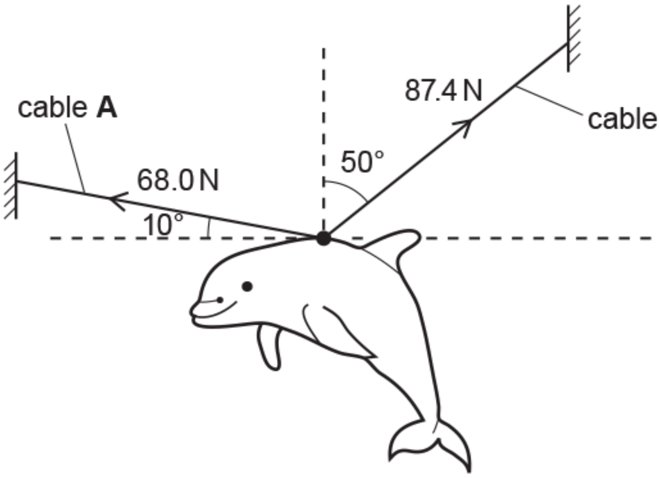


Fig. 21.2

The tension in cable **A** is 68.0 N and it makes an angle of 10° to the horizontal. The tension in cable **B** is 87.4 N and it makes an angle of 50° to the vertical.

i. Calculate the **total** vertical force F supplied by cables **A** and **B** by resolving the tensions in cables **A** and **B**.

F = ... N **[2]**

ii. Use your answer from **(i)** to calculate the mass m of the dolphin.

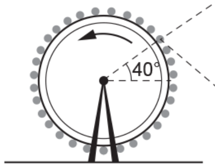
m = ... kg **[2]**

iii. The cables **A** and **B** have the same length and cross-sectional area.
The material of cable **B** has Young modulus 1.29E, where E is the Young modulus of the material of cable **A**.
Both cables obey Hooke's law.

Calculate the ratio $\frac{\text{extension of cable } \mathbf{B}}{\text{extension of cable } \mathbf{A}}$.

ratio = ... **[2]**

43. The London Eye, shown rotating anticlockwise in **Fig. 6.1**, is a giant wheel which rotates slowly at a constant speed.



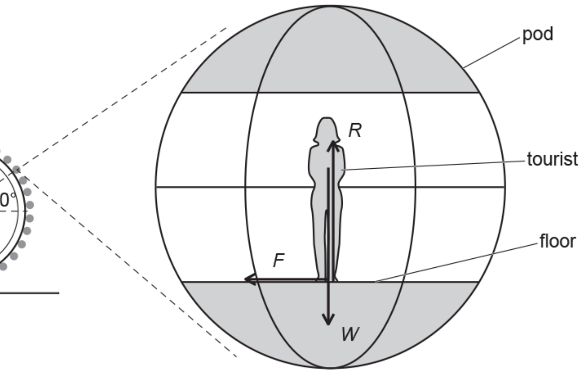


Fig. 6.1 **Fig. 6.2**

Tourists stand in pods around the circumference of the wheel.
The floor remains horizontal at all times.
At time t = 0, a tourist who has a weight W of 650 N enters a pod at the bottom of the wheel.
Fig. 6.2 shows the forces acting on the tourist at a later time, when the angle between the pod's position and the centre of the wheel is 40° above the horizontal. R is the normal contact force and F is friction.

The resultant upward force (R – W) on the tourist changes during the 30 minutes of the rotation of the London Eye as shown in **Fig. 6.3**.

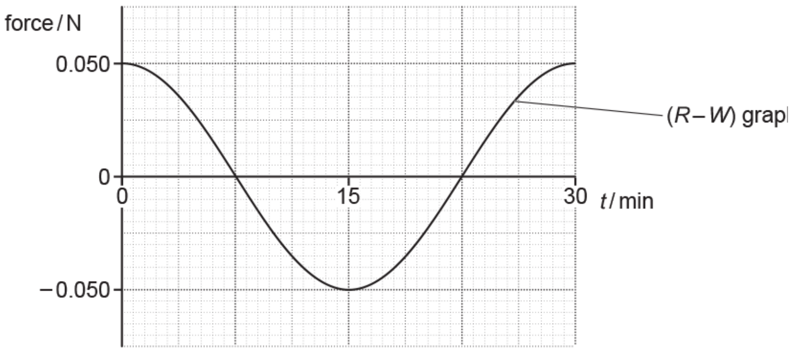


Fig. 6.3

i. Explain why the horizontal force F between the floor and the tourist is necessary.

[2]

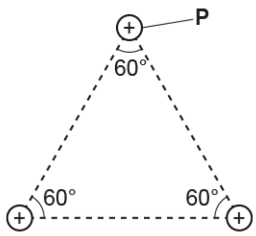
ii. Draw on **Fig. 6.3** the variation of the horizontal force *F* during the 30 minutes of the anticlockwise rotation of the London Eye. Take forces to the right to be positive.

[2]

iii. Calculate the magnitude of force *F* when the pod is at the position shown in **Fig. 6.2**, at 40° above the horizontal.

F = ...N**[2]**

44. The diagram below shows the arrangement of the 3 protons inside the nucleus of lithium-6 (^6_3Li).



The separation between each proton is about 1.0 × 10^{-15} m.

i. Calculate the magnitude of the repulsive electric force *F* experienced by the proton **P**.

F = ... N **[4]**

ii. On the diagram above, draw an arrow to show the direction of the electric force *F* experienced by **P**.

[1]

iii. Explain how protons stay within the nucleus of lithium-6.

[2]

END OF QUESTION PAPER