Cowen Physics

OCR Physics A

Vectors

Exam Pack

2 **(a)** The list below contains scalar and vector quantities.

pressure speed force power acceleration displacement

(i) Underline **all** of the vector quantities. **[1]**

(ii) List **two** quantities which when multiplied together give a quantity having the unit joule (J).

..... **[1]**

(iii) Name the quantity having the unit $kg\,m\,s^{-2}$.

..... **[1]**

(b) A hot air balloon rises with a vertical velocity of $7.0\,m\,s^{-1}$. A steady wind pushes the balloon with a horizontal velocity *v*.

Fig. 2.1 shows the velocity vectors for the balloon and the wind.

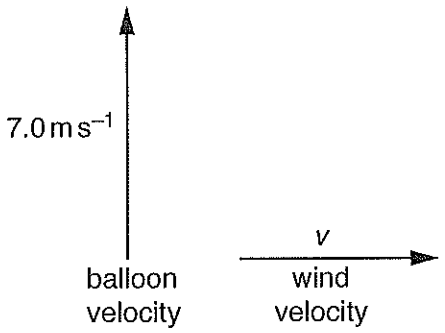


Fig. 2.1 (not to scale)

The magnitude of the resultant velocity of the balloon is $8.8\,m\,s^{-1}$.

(i) On Fig. 2.1, draw an arrow labelled **R** to show the approximate direction of the resultant velocity of the balloon. **[1]**

(ii) State why the magnitude of the resultant velocity of the balloon is not the sum of the speeds of the balloon and the wind.

.....

..... **[1]**

(iii) With the help of a vector triangle, determine the magnitude of the wind velocity v and the angle θ between the resultant velocity of the balloon and the horizontal.

v = ... $m\,s^{-1}$

θ = ...° **[4]**

(iv) Fig. 2.2 shows another balloon travelling with constant velocity $9.3\,m\,s^{-1}$.

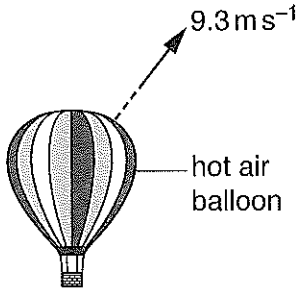


Fig. 2.2

Apart from the upthrust and the wind there are two other forces acting on the balloon.
State these two forces.
Draw labelled arrows on Fig. 2.2 to indicate their approximate directions.
State the direction of the resultant of these two forces.

.....

.....

..... **[3]**

Question			Answer	Marks	Guidance
2	a	i	force, acceleration and displacement all underlined.	B1	
		ii	force and displacement	B1	**Not** force and distance
		iii	Force	B1	
	b	i	An arrow at an angle upwards and to the right	B1	Allow a single arrow without the label **R**
		ii	(The resultant velocity is not the sum of the speeds because) velocity is a vector quantity / velocity (also) has direction (AW)	B1	
		iii	A suitable vector triangle with at least **two** vectors correctly labelled $8.8^2 = 7.0^2 + v^2$ (Any subject) $v = 5.3$ (m s^{-1}) $\theta = 53°$	B1 C1 A1 A1	**Note**: Ignore arrows **Allow** full credit for a scale drawing when v is within $\pm$ 0.1 m s^{-1} and θ is within $\pm$ 1°
		iv	Weight acts vertically down Drag / air resistance is opposite to the direction of the velocity (9.3 m s^{-1}) The resultant of the two forces is downward and to the left and at a greater angle to the horizontal (or steeper) than the velocity (9.3 m s^{-1}) vector / between drag and weight	B1 B1 B1	**Allow** use of labelled diagram
			Total	**12**	

SECTION B

Answer **all** the questions

21 **(a)** State what is meant by a *vector quantity* and give one example.

.....

.....

..... **[1]**

(b) **Fig. 21.1** shows a toy locomotive on a circular track of radius 0.60 m.

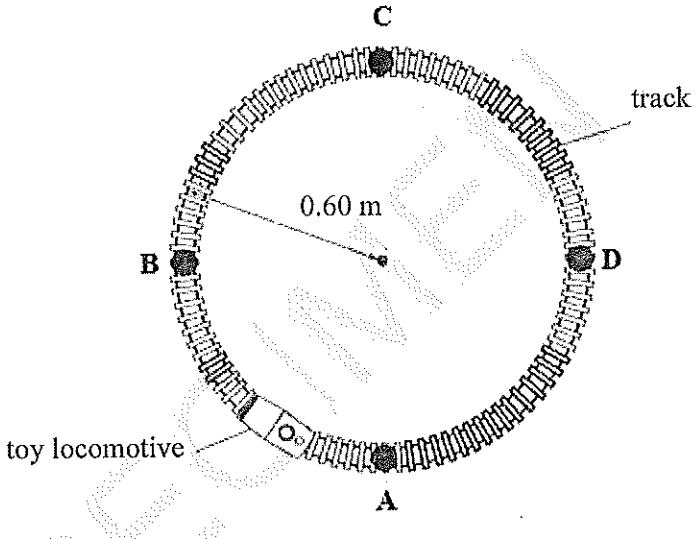


Fig. 21.1

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.

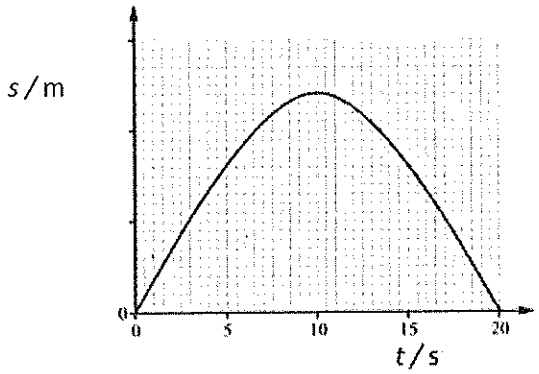


Fig. 21.2

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

.....

.....

..... [2]

(c) 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.

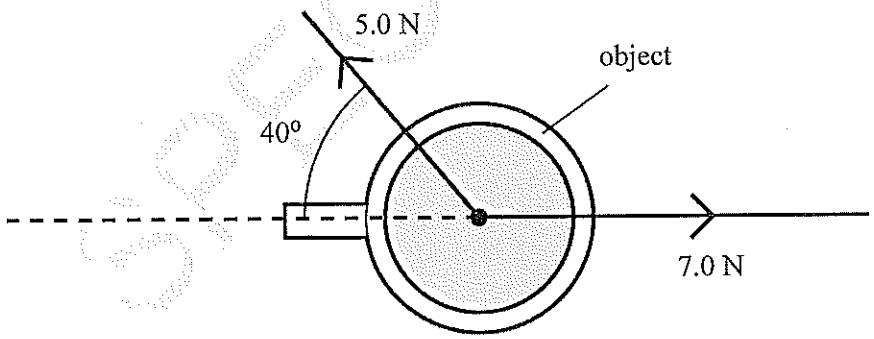


Fig. 21.3

The mass of the object is 320 g.

Calculate the magnitude of the acceleration of the object.

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

SECTION B

Question			Answer	Marks	Guidance
21	(a)		A quantity that has both direction and magnitude. Correct example given, e.g. velocity.	B1	**Note:** The B1 mark is for a correct statement and a correct example.
	(b)	(i)	speed = $\frac{2 \times \pi \times 0.60}{20}$ speed = 0.19 (m s^{-1})	C1 A1	
		(ii)	Displacement is the direct distance of the locomotive from **A**, so the graph is symmetrical about t = 10 s. At t = 20 s it returns back to **A or** at t = 10 s it is 1.2 m from **A or** at t = 10 s, it is at **C**.	B1 B1	
	(c)		resultant force = $(7.0^2 + 5.0^2 - 2 \times 7.0 \times 5.0 \times \cos 40)^{1/2}$ resultant force = 4.51 (N) acceleration = 4.51/0.320 = 14 (m s^{-2})	C1 C1 A1	**Allow:** resultant force = $[(7.0 - 5.0\times\cos 40)^2 + (5.0\times\sin 40)^2]^{1/2}$ **Allow** full marks for a correct scale drawing to determine the resultant force; resultant force = 4.5 ± 0.1 N **Allow** full marks for resolving into horizontal and vertical components and combining correctly.
			Total	8	

Answer **all** the questions.

1 In each of the following questions a description of a graph is given.

Insert the correct labels for the axes on the dotted lines in Fig. 1.1 to Fig. 1.4.

The first one has been completed for you.

The area under the graph shown in Fig. 1.1 is equal to the elastic potential energy of a spring.

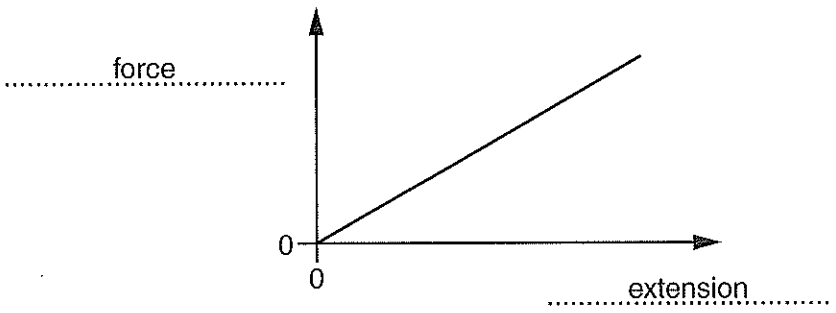


Fig. 1.1

(a) The area under the graph shown in Fig. 1.2 is equal to the displacement of a ball.

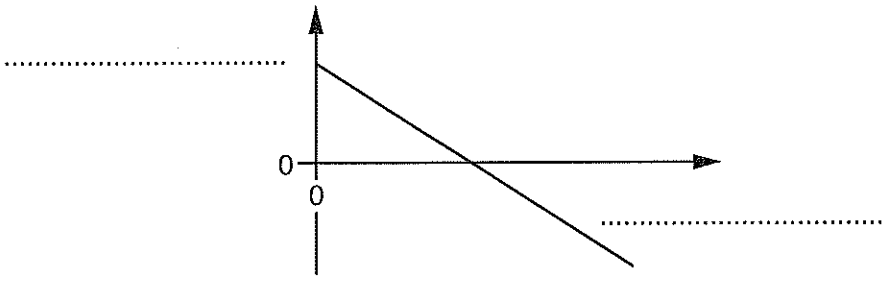


Fig. 1.2

[1]

(b) The gradient of the graph shown in Fig. 1.3 is the Young modulus of a material.

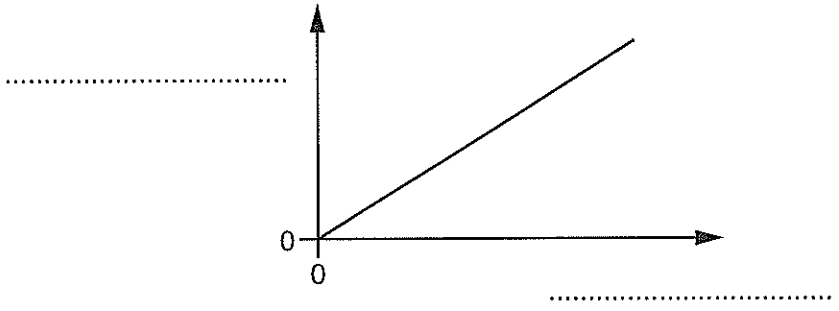


Fig. 1.3

[1]

(c) The gradient of the graph shown in Fig. 1.4 is the force constant of a wire.

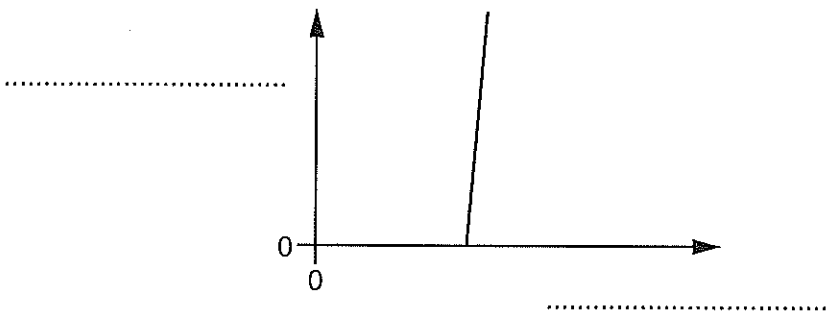


Fig. 1.4

[1]

Turn over for next question

2 **(a)** *Energy* and *work done* are scalar quantities and have the same unit as each other.

State **two** other scalar quantities in physics that have the same unit as each other.

.....

..... **[1]**

(b) Two forces **A** and **B** act through the same point in an object. These two forces are shown in Fig. 2.1. No other forces act on the object.

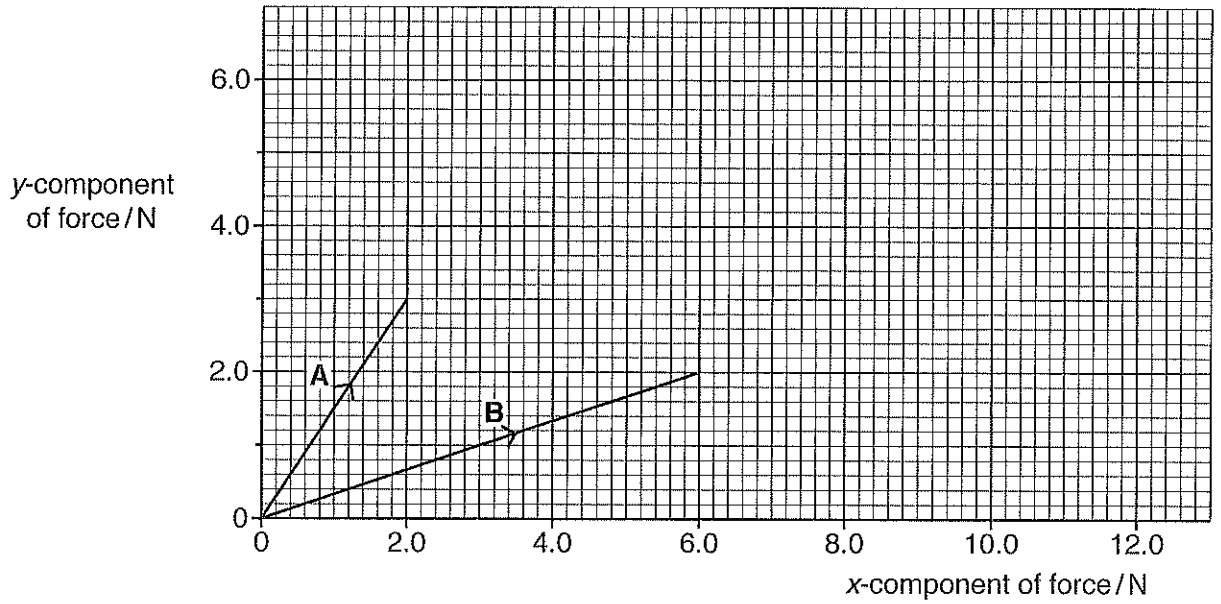


Fig. 2.1

(i) Use Fig. 2.1 to determine the *x*- and *y*- components of the force **B**.

x-component = ... N

y-component = ... N
[1]

(ii) Use Fig. 2.1 to determine the magnitude of the resultant of the two forces **A** and **B**.

resultant force = ... N **[3]**

(c) Fig. 2.2 shows a jet of water from the end of a hosepipe.

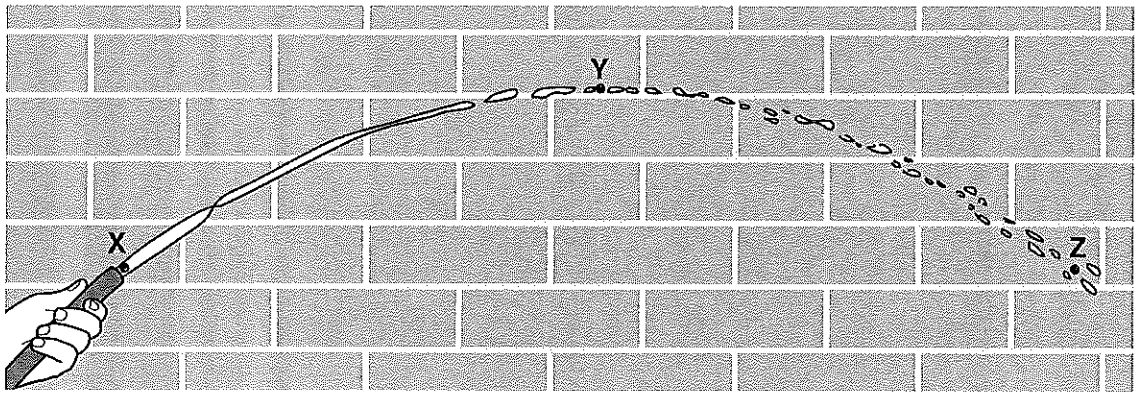


Fig. 2.2

Air resistance has negligible effect on the motion of the water jet. The water jet reaches maximum height at point **Y**.

(i) State the direction of the force acting on the water at **Y**.

.....[1]

(ii) Describe and explain how the horizontal component of the velocity of the water varies from point **X** to point **Y**.

.....

.....

.....

.....

.....[2]

(iii) Describe how the vertical component of the velocity of the water varies from point **X** to point **Z**.

.....

.....

.....

.....

.....

.....[2]

Question			Answer	Marks	Guidance
1	a		velocity against time	B1	**Not** 'speed' for velocity **Not** time against velocity Ignore units
	b		stress against strain	B1	Ignore units
	c		force / load / tension against length (of wire)	B1	**Not** force against extension **Not** 'weight' for force **Not** 'distance' for length Ignore units
			Total	**3**	

Question			Answer	Marks	Guidance
2	a		pressure and stress or pressure and Young modulus or stress and Young modulus or moment (of a force) and torque (of a couple)	B1	**Allow** other correct combinations **Allow** the following: • e.m.f. and p.d. • Any two from frequency, activity, decay constant and Hubble constant because of the s^{-1} **Ignore** any units given (even if incorrect) **Special case**: Allow quantities with no units, e.g. strain and efficiency. **Not** any combination of length, distance and extension
	b	i	*x*-component = 6.0 (N) and *y*-component = 2.0 (N)	B1	**Allow** 1 sf answers **Allow** tolerance ± 0.1 N **Not** *x*-component = 2.0 (N) and *y*-component = 6.0 (N)
		ii	resultant components are 8.0 (N) and 5.0 (N) $F^2 = 8.0^2 + 5.0^2$ force = 9.4 (N)	C1 C1 A1	**Allow**: 1 sf values for this C1 mark Possible ecf from **(b)(i)** with *x*-components = 2 + **b(i)** and *y*-component = 3 + **b(i)**. **Note**: Answer is 9.43 to 3sf **Not** an answer left in square root form, e.g $\sqrt{89}$ **Allow** full credit for a scale drawing; marks awarded as below: • A dot / cross / mark at 8.0,5.0 (± 0.1) C1 • Line drawn from 0,0 to 8.0,5.0 C1 • force = 9.4 ± 0.1 (N) A1
	c	i	Down	B1	**Allow** a downward arrow on Fig. 2.2

Question			Answer	Marks	Guidance
		ii	Horizontal component of the velocity is constant There is no horizontal force	B1 B1	**Allow**: There is no horizontal acceleration **Allow**: Weight / *g* has no horizontal component or Weight / *g* is 90° to the horizontal or Weight / *g* is vertical or 'there is only a vertical force' (**Not** 'gravity' for 'weight'; allow 'force of gravity')
		iii	Any two from: • It decreases from **X** to **Y** • It is zero at **Y** / It has the same magnitude at **X** and Z • It increases from **Y** to **Z** • It is positive from **X** to **Y** and negative from **Y** to **Z** (or vice versa)	B1 × 2	**Ignore** description in terms of acceleration or deceleration **Allow** it changes sign / direction from **X** to **Z**
			Total	**10**	

Answer **all** the questions.

1 **(a)** **(i)** State the difference between a scalar and a vector quantity.

.....

.....[1]

(ii) Underline the vector quantities in the list below.

acceleration density force kinetic energy power volume weight

[2]

(b) Fig. 1.1 shows the path of a ball that is thrown from point **A** to point **B**. The ball reaches its maximum height at point **H**.

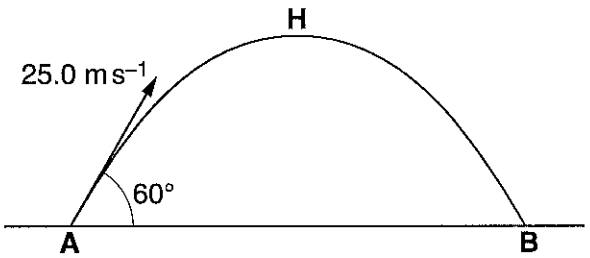


Fig. 1.1

The ball is thrown with an initial velocity of $25.0\,m\,s^{-1}$ at 60° to the horizontal. Assume that there is no air resistance.

(i) **1** Show that the vertical component of the initial velocity is $21.7\,m\,s^{-1}$.

[1]

2 Calculate the time taken for the ball to reach point **H**.

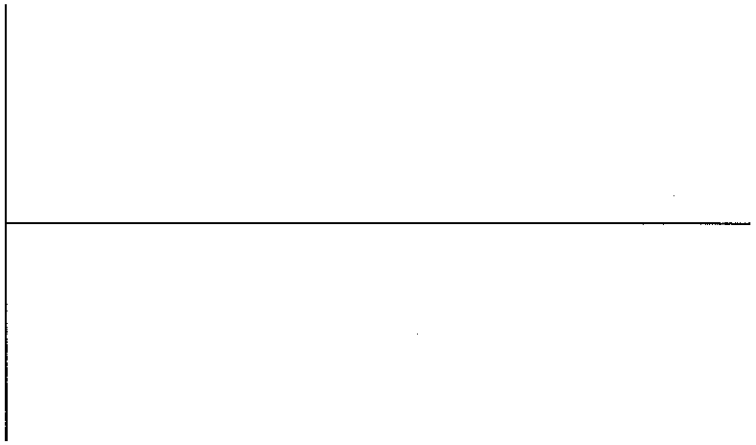
time = ... s [2]

3 Calculate the displacement from **A** to **B**.

displacement = ... m [3]

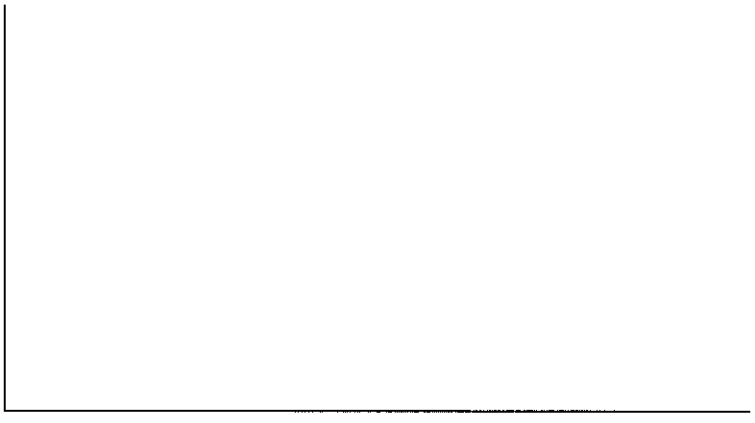
(ii) For the path of the ball shown in Fig. 1.1, draw sketch graphs, with labelled axes but without numerical values, to show the variation of

1 the vertical component of the ball's velocity against time



[3]

2 the distance travelled along its path against time.



[2]

In this part of the question, one mark is available for the quality of written communication.

(iii) Assuming no air resistance, describe the forms of energy possessed by the ball at **A**, **H** and **B** and how the energy changes between these points.

.....

.....

.....

.....

.....

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.....

.....

.....[4]

Quality of Written Communication [1]

[Total: 19]

2 (a) (i) State the conditions for a system to be in equilibrium.

.....

.....

.....

.....[2]

(ii) Define the *moment of a force*.

.....

.....[1]

(b) Fig. 2.1 shows a system for supporting a load.

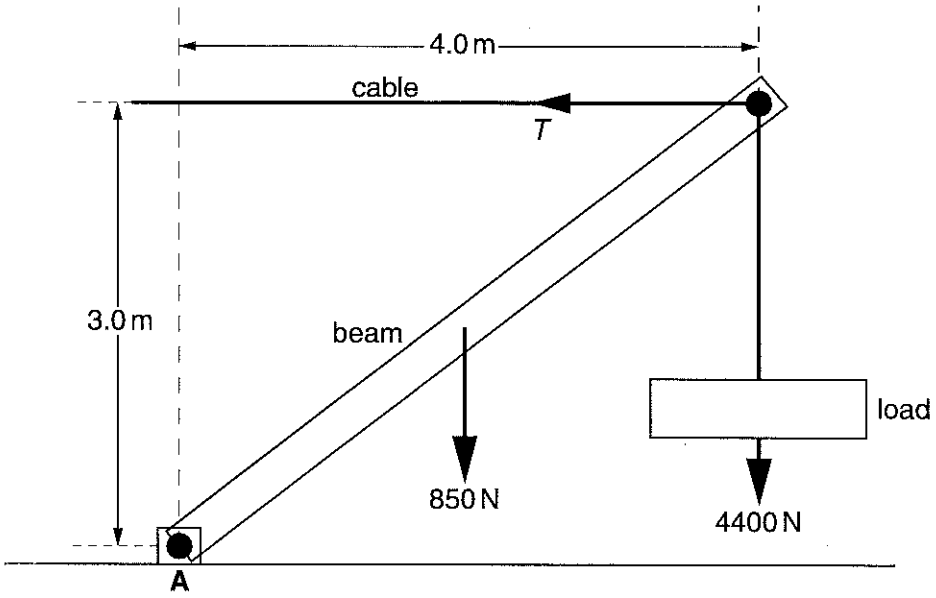


Fig. 2.1

The load of weight 4400 N is hanging from a uniform beam that is supported by a horizontal cable. The beam has a weight of 850 N and is hinged at **A**.

(i) Take moments about **A** and show that the tension T in the cable is 6400 N (to 2 significant figures).

[3]

(ii) State and explain what force, in addition to those shown, must act on the beam to keep it in equilibrium. You are not expected to calculate this force.
Draw this force on Fig. 2.1 and label it **F**.

.....

.....

.....

.....[2]

[Total: 8]

2821 Forces and Motion

Question			Expected Answers	Marks	Additional Guidance
1	a	i	A vector has a direction	B1	This is the minimum required. The reverse argument that a scalar does not have a direction can be implied. Allow extra comments such as magnitude, size, number and quantity but identified quantities such as a scalar has a distance and a vector has a distance and direction should **not** be allowed.
		ii	[acceleration, force and weight] 3 correct scores 2 2 correct scores 1. (–1 for incorrect scalar answers)	B2	e.g, acceleration, force and power would score 0 (+1 and -1) acceleration, force, power and weight would score1 (+2 and -1)
	b	i 1	(v_v =) 25 sin60 or 25cos30 = 21.7 (21.65) (m s^{-1})	M1 A0	
		2	v = u + at 0 = 21.7 – (9.81 x t) t = 2.2(1) (s)	C1 A1	Or t = (v-u) / a or a = (v-u) / t Do not accept t = 2 (**SF** error). If g=10 used then penalise -1 but only once on the paper
		3	distance = speed x time	M0	Any equation with acceleration cannot score these marks unless a=0 stated
			using speed = 25 cos60 or 25sin30	C1	Correct horizontal component (12.5)
			using time = 2t	C1	Note **ECF** from **(b)(i) 2**
			= 55(.2) (m)	A1	

Question			Expected Answers	Marks	Additional Guidance
		ii 1	straight line negative / positive gradient	B1	The velocity must start from a non zero point and be a straight line as far as the time axis
			line continues into negative / positive v values with the same gradient	B1	
			same time in both + and – regions and to same v (only if correct line drawn)	B1	If time not labelled at half way mark, then use the ruler available to check times and allow 3 mm difference. Judge velocities by eye
		2	decreasing gradient	B1	But not reaching a vertical line at end
			increasing gradient (roughly same gradient at beginning and end)	B1	
	b	iii	ANY FOUR: PE zero or minimum at A / rises from A to H / maximum at H / falls from H to B.		Only one of these is required for the mark **but** any further contradictions about the PE would cancel this mark.
			KE max at A / falls from A to H / rises from H to B.		Similarly for the KE statements
			KE is a <u>minimum</u> at H (*not zero)*		The candidate's first four statements should be marked with **a cross or a tick** on script and the remainder checked for contradictions only.
			KE is <u>converted</u> to PE / PE is <u>converted</u> to KE / <u>loss</u> in PE = <u>gain</u> in KE		**Do not allow or penalise:** PE = KE half way up (AW)
			KE / PE at B is the <u>same</u> as at A	MAX B4	
		QWC	Spelling and punctuation	B1	Penalise if more than two errors in spelling or punctuation. No tick or cross needed. Allow GPE and KE
			Total	19	

Question			Expected Answers	Marks	Additional Guidance
2	a	i	**Resultant force or sum of forces is zero** **Resultant or sum of torque / moments is zero**	**B1** **B1**	**Do not allow**: upward forces equal downward forces / forces are balanced / all forces are equal (and opposite) **Allow:** sum of clockwise moments equals sum of anticlockwise moments
		ii	**Force x perpendicular distance from the pivot / point / axis**	**B1**	
	b	i	**850 x 2 or 4400 x 4 or T x 3** **(Sum of clockwise =) 850 x 2 + 4400 x 4** **equating this sum with the anticlockwise moment T x 3 and solving to give T = 6400 (6433) (N)**	**B1** **B1** **B1**	Any correct moment scores the first mark The two correct clockwise moments added The clockwise and anticlockwise moments are then equated and solved and not just the clockwise divided by 3
		ii	**Force at A drawn up and to the right of vertical allow up to parallel with beam** **Another force is required to give zero resultant force or up and down / left and right forces do not balance**	**B1** **B1**	Mark diagram with **a tick or cross** to show F has been looked for Do not accept the system is not in equilibrium (that is in the question)
			Total	**8**	

Answer **all** the questions.

1 **(a)** State the difference between a vector and a scalar quantity.

.....

..... **[1]**

(b) In the following list underline **all** the scalar quantities.

displacement kinetic energy mass power velocity weight **[1]**

(c) Fig. 1.1 shows a climber on a vertical rock face supported by a rope. The climber is in equilibrium.

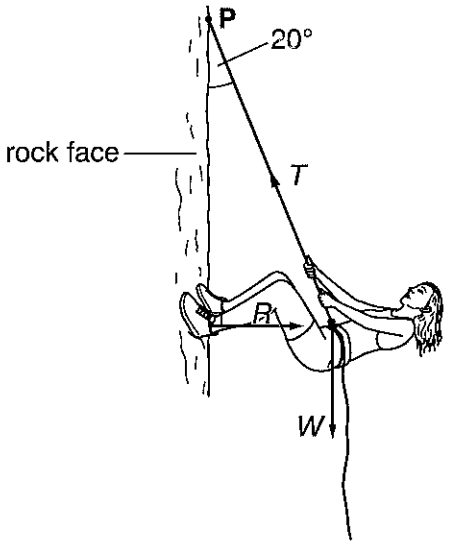


Fig. 1.1

The weight of the climber and her equipment is 650 N. The rope is attached to the climber and fixed to a point **P** where it makes an angle of 20° to the vertical. The contact force R acts on the climber at right angles to the rock face.

(i) Use a vector triangle or resolve forces to calculate

1 the tension T in the rope

$T =$ ..... N

2 the contact force R.

$R =$ ..... N

[3]

(ii) The climber moves down the rock face and the angle the rope makes with the vertical decreases. Explain why the magnitude of the tension decreases.

.....

.....

..... **[1]**

[Total: 6]

2821 Forces and Motion

Question 1			Expected Answers	Marks	Additional Guidance
(a)			A vector <u>has a direction</u>	B1	Ignore additional comments unless there is a contradiction
(b)			Kinetic energy, mass and power all correct (no others underlined)	B1	
(c)	(i)	1	Tcos20 = W (W = 650) T = 692 (N) allow 2 sf	C1 A1	Solution involving triangles: correct triangle and three arrows C1 Scale diagram requires scale and correct triangle (no arrows)C1 allow +/- of 20 (N) for scale diagram do not allow 691 (N) but penalise only once on the paper
		2	Tsin20 = R R = 692sin20 = 237 236(.6) (N) Allow 240 (N)	A1	Allow ecf for T from (c)(i)1 Allow +/- 220 to 250 (N) for scale diagram Correct answer for 1 and 2 **in reverse** can score 1 mark
	(ii)		With the angle made with rock face less the tension is closer to equalling the weight value or example quoted cos10 is greater than cos20 i.e. closer to one	A1	Expect clear answer here. Do not allow answers such as R decreases therefore T increases. Allow answers that refer to cos angle is greater (for smaller angles) hence T will be less
			Total	6	

Answer **all** the questions.

1 **(a)** State a similarity and a difference between *distance* and *displacement*.

(i) similarity: .....

..... **[1]**

(ii) difference: .....

..... **[1]**

(b) Fig. 1.1 shows two airports **A** and **C**.

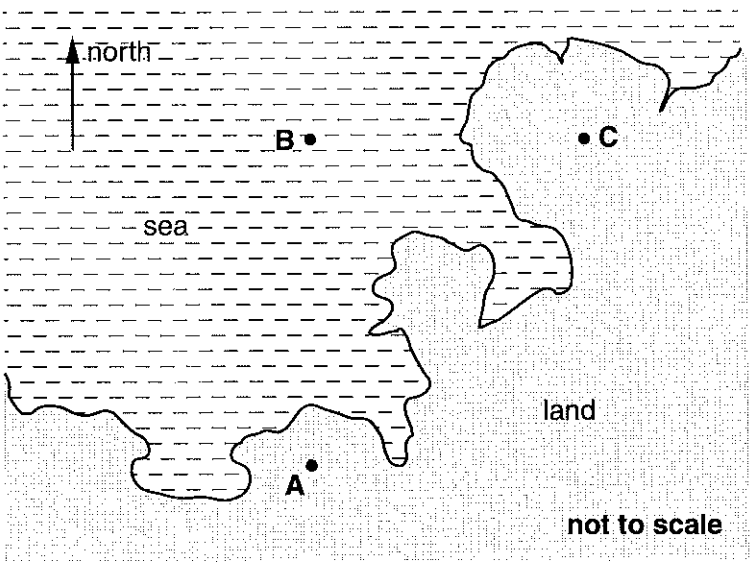


Fig. 1.1

An aircraft flies due north from **A** for a distance of 360 km (3.6×10^5 m) to point **B**. Its average speed between **A** and **B** is 170 m s^{-1}. At **B** the aircraft is forced to change course and flies due east for a distance of 100 km to arrive at **C**.

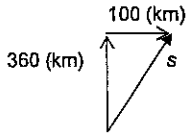
(i) Calculate the time of the journey from **A** to **B**.

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

(ii) Draw a labelled displacement vector triangle below. Use it to determine the magnitude of the displacement in km of the aircraft at **C** from **A**.

displacement = ... km **[3]**

[Total: 6]

Question			Expected Answers	Marks	Additional Guidance
1	(a)	(i)	Both measured in metre/m	B1	**Allow**: Both have the same unit/Both have 'magnitude' **Not**: Both are distance/length
		(ii)	Distance is a scalar/does not have direction or Displacement is a vector/has direction	B1	**Not**: One is a vector and the other a scalar
	(b)	(i)	time = $\frac{3.6\times10^5}{170}$ time = 2.1(18) × 10^3 (s) or 2.1 × 10^3 (s)	B1	**Note**: Answer to 2sf or more is required
		(ii)	Correct vector triangle Eg:  $s^2 = 360^2 + 100^2$ / $s = \sqrt{(360^2 + 100^2)}$ s = 373.6 (km) / 370 (km)	B1 C1 A1	The vector triangle must have at least two labels (360, 100 and *s* – allow *x* or *d* for *s*). The 'orientation' of the triangle must be as shown. Ignore the direction of the arrows. **Allow**: Full credit can be given for a scale drawing 2 marks if answer in the range (370 – 380) 1 mark if answer in the range (360 – 370) or (380 - 390) **Note**: Bald answer to 2sf or more and no diagram scores 2/3 marks.
			Total	**6**	

4 **(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.

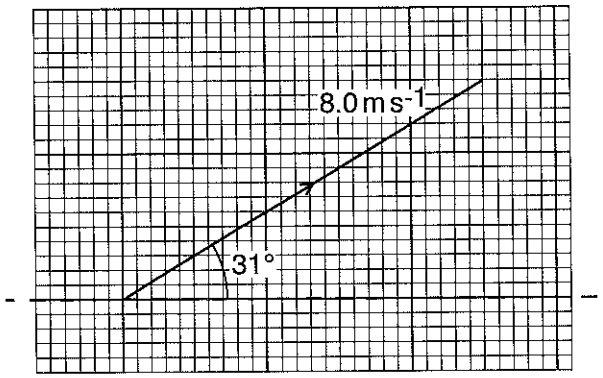


Fig. 4.1

(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]**

(c) Fig. 4.2 shows a ship **S** being pulled by two tug-boats.

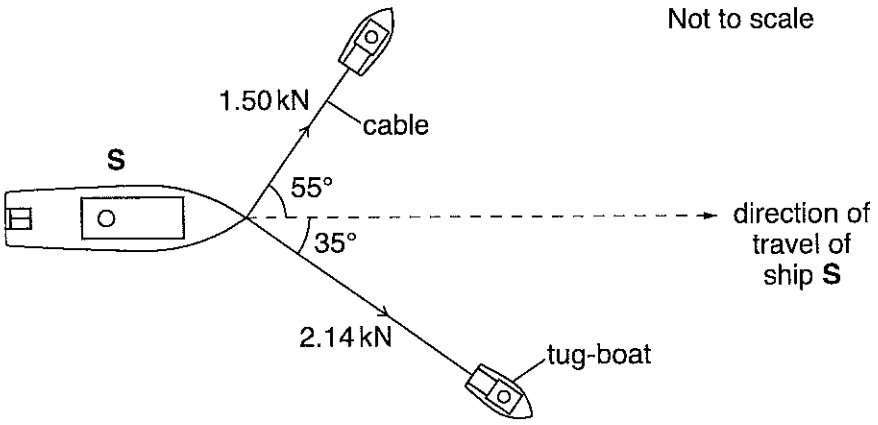


Fig. 4.2

The ship is travelling at a constant velocity. The tensions in the cables and the angles made by these cables to the direction in which the ship travels are shown in Fig. 4.2.

(i) Draw a vector triangle and determine the resultant force provided by the two cables.

resultant force = ... kN **[3]**

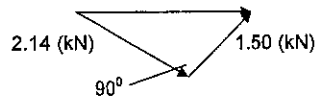
(ii) State the value of the drag force acting on the ship **S**. Explain your answer.

.....

.....

..... **[2]**

[Total: 10]

Question			Expected Answers	Marks	Additional Guidance
4	(a)		The mass (of the electron) increases as its speed approaches c / speed of light / 3×10^8 m s^{-1}	M1 A1	**Not**: mass 'changes' / 'electron becomes heavier'
	(b)	(i)	A line with correct arrow in the *y* direction has length of 14 to 16 'small squares'	B1	
			A line with correct arrow in the *x* direction has length of 24 to 26 'small squares'	B1	**Note**: If correct arrows are not shown, then maximum mark is 1
		(ii)	component = $(8.0\cos 31 =) 6.86$ (m s^{-1}) or 6.9 (m s^{-1})	B1	**Allow**: 6.85 as BOD
	(c)	(i)	Correct vector triangle drawn  	B1	**Note**: Expect at least one 'label' on the sketch, eg: 2.14, 1.5, 90^0 The 'orientation' of the triangle is not important The directions of all three arrows are required
			(resultant force)^2 = $2.14^2 + 1.50^2$	C1	
			resultant force = 2.61 (kN)	A1	**Allow**: 2 sf answer of 2.6 (kN) **Allow** a scale drawing; 2 marks if answer is within ±0.1 kN and 1 mark if ± 0.2 kN **Alternative** for the C1 A1 marks: 1.50cos(55) or 2.14cos(35) C1 resultant force = 1.50cos(55) + 2.14cos(35) resultant force = 2.61 (kN) A1
		(ii)	2.6(1) (kN)	B1	Possible ecf
			(Constant velocity implies) zero net force / zero acceleration	B1	**Not**: '*resultant force* = *drag*' since the first B1 assumes this
			Total	**10**	

5 Use your knowledge of physics to state if each statement is correct or incorrect. You then need to explain the reason for your answer. An example has been done for you:

In a vacuum, a 2.0 kg object will fall faster towards the ground than an object of mass 1.0 kg.

This statement is **incorrect**.
Explanation: **All objects falling towards the Earth in a vacuum have the same acceleration.**

(a) The mass of a particle (e.g. electron) remains constant as its speed approaches the speed of light.

This statement is .....

Explanation: .....

.....

..... **[2]**

(b) A ball is thrown vertically upwards. Air resistance has negligible effect on its motion. During the flight, the total energy of the ball remains constant.

This statement is .....

Explanation: .....

.....

..... **[2]**

(c) An object falling through air has a terminal velocity of $30\,m\,s^{-1}$. At terminal velocity, the weight of the object is equal to the acceleration of free fall.

This statement is .....

Explanation: .....

.....

..... **[2]**

(d) The technique of 'triangle of vectors' is used by a global positioning system (GPS) to locate the position of cars.

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

This statement is .....

Explanation: .....

.....

..... **[2]**

[Total: 8]

Q5	Expected Answers	Marks	Additional Guidance
a	...incorrect Mass (of the particle) increases (as it approaches speed of light)	M1 A1	**In question 5, use tick or cross on Scoris to show if the mark is awarded** **Not**: mass *changes*
b	....correct KE is changed into (G)PE or (G)PE is changed into KE or change in KE = change in (G)PE (AW)	M1 A1	**Note**: This mark is for stating the transfer of energy between kinetic and (gravitational) potential
c	...incorrect Weight is equal to drag / air resistance / friction (and not acceleration of free fall)	M1 A1	Allow **alternative** response: ..... incorrect M1 Acceleration and weight are not the same quantities (AW) A1
d	...incorrect The technique is trilateration ✍ **The term *trilateration* to be included and spelled correctly to gain the A1 mark**	M1 A1	**Note** 1 mark if 'trilateration' is misspelled but candidate has mentioned that the statement is incorrect
	Total	**8**	

3 **(a)** Define a *vector* quantity and give one example.

.....

..... **[2]**

(b) Fig. 3.1 shows a force F at an angle of 30° to the horizontal direction.

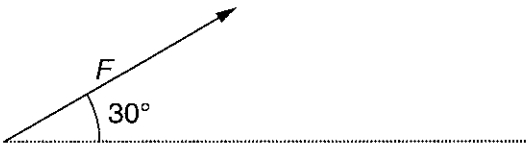


Fig. 3.1

(i) The **horizontal component** of the force F is 7.0 N. Calculate the magnitude of the force F.

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

(ii) The force F moves an object in the horizontal direction. In a time of 4.2 s, the object moves a horizontal distance of 5.0 m. Calculate

1 the work done by the force

work done = ... J **[2]**

2 the rate of work done by the force.

rate of work done = ... W **[1]**

(c) Fig. 3.2 shows the forces acting on a stage light of weight 120 N held stationary by two separate cables.

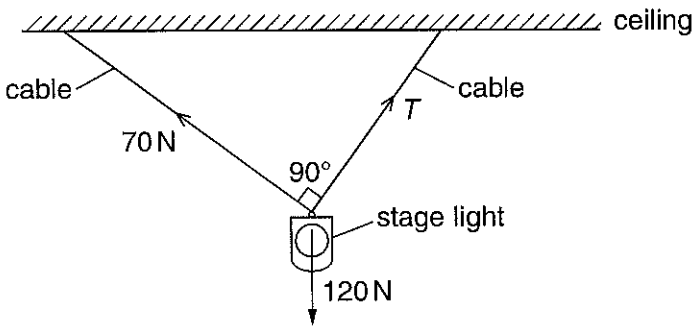


Fig. 3.2

The angle between the two cables is 90°. One cable has tension 70 N and the other has tension T.

(i) State the magnitude and the direction of the **resultant** of the tensions in the two cables.

magnitude .....

direction ..... **[2]**

(ii) Sketch a labelled vector triangle for the forces acting on the stage light. Hence, determine the magnitude of the tension T.

T = ... N **[4]**

[Total: 13]

Question			Expected Answers	Marks	Additional Guidance
3	a		A quantity with magnitude / size and direction Suitable example: displacement / velocity / acceleration / force / weight etc	B1 B1	
	b	i	$F_x = F\cos\theta$ $7.0 = F \times \cos 30$ $F = 8.1$ (N) or 8.08 (N)	C1 A1	**Allow**: 1 mark for 'radian' error; answer is 45.3 (N) **Note**: No marks for '$7.0 \times \cos 30 = 6.06$ N'
		ii	**1** $W = 7.0 \times 5.0$ or $W = 8.08 \times 5.0 \times \cos 30$ work done = 35 (J) **2** 'power' = 35/4.2 = 8.3 (W)	C1 A1 B1	Possible ecf **Note**: If answer for **(b)(i)** is 6.06 (N), then '$6.06 \times 5.0 \times \cos 30 = 26.2$ (J)' scores 2/2 because of ecf Possible ecf
	c	i	Magnitude is 120 (N) / equal to weight Direction is (vertically) up / opposite to weight	B1 B1	
		ii	Correct diagram Correct detail on diagram $120^2 = 70^2 + T^2$ $T = 97$ (N) or 97.5 (N)	M1 A1 C1 A1	**Note**: For the M1 mark, the basic diagram must have all sides labelled (70, 120 and T) and the angle between 70 (N) and T is judged by eye to be 90° **Note**: For the A1 mark, all the arrows are marked and cyclic **Note**: For the C1 A1 marks, $T = \sqrt{120^2 + 70^2} = 140$ scores zero **Allow:** 2 marks for T in the range of 94 (N) to 100 (N) if scale drawing is done
			Total	**13**	

Answer **all** the questions.

1 **(a)** State **one** difference between a scalar quantity and a vector quantity.

.....

..... **[1]**

(b) Fig. 1.1 shows two sets of quantities listed as 'scalars' and 'vectors' by a student.

scalars	vectors
acceleration	displacement
pressure	energy
stress	power
time	velocity
volume	weight

Fig. 1.1

(i) State the one quantity that has been incorrectly listed as a scalar.

..... **[1]**

(ii) State two quantities that have been incorrectly listed as vectors.

1. .....

2. ..... **[1]**

(iii) State two quantities listed as scalars that have the same unit. Name this unit.

1. .....

2. .....

unit: ..... **[2]**

(c) Circle the correct value for the prefix tera (T) in the list below.

10^6 10^9 10^{12} 10^{15} **[1]**

(d) Rearrange the following prefixes in the order of smallest to largest.

μ c p k

..... **[1]**

[Total: 7]

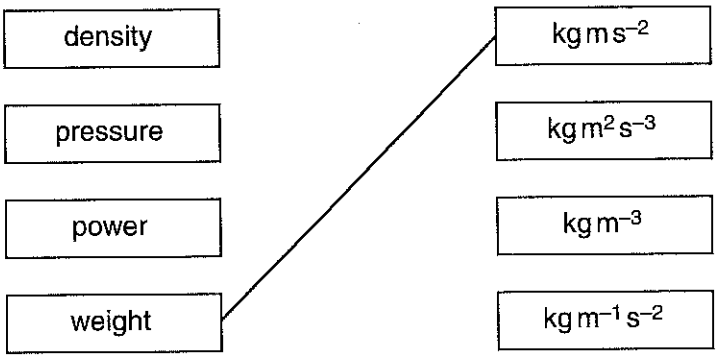
Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more sf.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Additional Guidance.

Question			Answer	Marks	Guidance
1	(a)		A vector quantity has direction / scalar quantity does not have direction	B1	**Not**: 'Scalar only has magnitude' because there is no mention of direction
	(b)	(i)	acceleration	B1	
		(ii)	power and energy	B1	
		(iii)	stress and pressure unit: pascal / Pa / N m^{-2} / kg m^{-1} s^{-2}	M1 A1	**Note**: The A1 mark can only be scored if M1 is awarded
	(c)		10^{12}	B1	
	(d)		*p μ c k*	B1	
			Total	7	

Answer **all** the questions.

1 Draw a line from each quantity on the left-hand side to the correct unit on the right-hand side. One quantity (weight) has already been matched to its unit.



[2]

[Total: 2]

2 **(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.

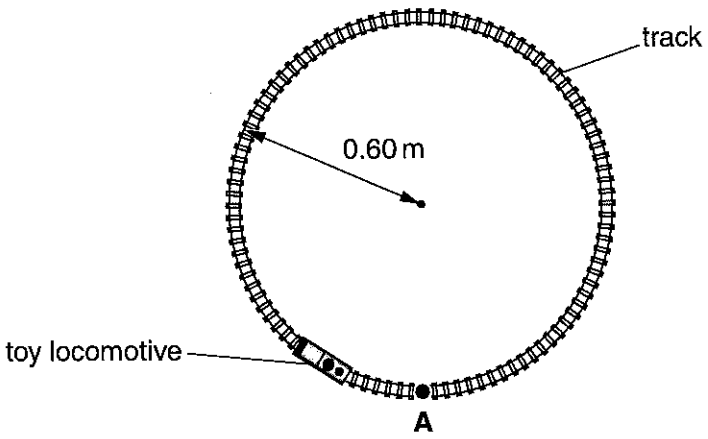


Fig. 2.1

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]

Note about significant figures and rounding errors:

If the data given in a question is to 2 sf, then allow answers to 2 or more sf. If an answer is given to fewer than 2 sf, then penalise once only in the entire paper. Any exception to this rule will be mentioned in the Guidance.
Penalise a rounding error once only in the entire paper.

Question			Answer	Marks	Guidance
1			Lines joining density to 'kg m^{-3}' pressure to 'kg m^{-1} s^{-2}' power to 'kg m^2 s^{-3}'	B1×2	**Note:** All correct – 2 marks, deduct 1 mark for each error or omission. (Minimum score = 0)
			Total	**2**	

Question			Answer	Marks	Guidance
2	(a)		Difference: Velocity / vector has direction (and speed does not) or speed / scalar does not have direction (velocity has) Similarity: Both have the same unit / both have m s^{-1} (as the unit) / both have magnitudes	B1 B1	**Not** 'velocity is a vector / speed is a scalar' since it is stated in the question
	(b)	(i)	distance = $2 \times \pi \times 0.60$ (= 3.77 m) / speed = $\frac{3.77}{12}$ speed = 0.31 (m s^{-1})	C1 A1	**Note**: Answer to 3 sf is 0.314 (m s^{-1})
		(ii)	$s^2 = 0.60^2 + 0.60^2$ s = 0.85 (m)	C1 A1	**Note**: Answer to 3 sf is 0.849 (m) **Note**: 0.72 scores 1 mark (square root omitted)
		(iii)	The (change in) displacement is zero	B1	
		(iv)	The direction changes (even though the magnitude is the same)	B1	
			Total	**8**	

2 **(a)** Explain why force is a *vector* quantity.

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

.....

..... **[1]**

(b) Fig. 2.1 shows the forces acting on a water drop on the windscreen of a stationary car.

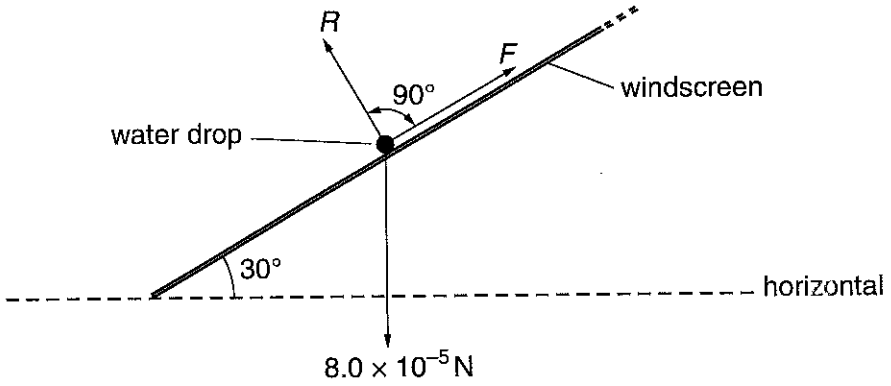


Fig. 2.1

The windscreen makes an angle of 30° to the horizontal. The weight of the water drop is 8.0×10^{-5} N. The normal contact force on the water drop is *R*. There is also a force *F* acting on the water drop as shown. The water drop is **stationary**.

(i) Use Fig. 2.1 to determine the component of the weight of the water drop

1 perpendicular to the windscreen

component = ... N

2 parallel to the windscreen.

component = ... N

[2]

(ii) Determine the magnitude of F. Explain your answer.

.....

.....

.....

..... **[2]**

[Total: 5]

Question 3 begins on page 6

Question			Answer	Marks	Guidance
1	(a)		N m^{-2} or N/m^2 or Pa m s^{-2} or m/s^2 or (kg) m s^{-2} 1000	B2	**Allow** any prefix given **Allow**: 2 marks if all three correct; 1 mark if one is correct or two are correct
	(b)		(volume =) 82 - 75 (cm^3) or 7 (cm^3) density = $\frac{1.6\times10^{-2}}{7\times10^{-6}}$ density = 2.3×10^3 (kg m^{-3})	C1 A1	**Allow**: 1 mark for 2.3×10^n, $n \neq 3$
			Total	**4**	

Question			Answer	Marks	Guidance
2	(a)		It has **direction** (and magnitude/size)	B1	**Note:** ✍ ***direction*** must be spelled correctly for the mark
	(b)	(i)	perpendicular component = 8.0×10^{-5} cos30 perpendicular component = 6.9×10^{-5} (N) parallel component = 8.0×10^{-5} sin30 parallel component = 4.0×10^{-5} (N) or 4×10^{-5} (N)	B1 B1	**Allow**: 1 mark if the correct numerical values of the components have been swapped **Note**: Penalise POT error once only; eg 6.9 and 4 respectively scores 1 mark **Note**: Calculator in radian mode gives 1.23×10^{-5} and (-) 7.90×10^{-5} (N); this scores 1 mark
		(ii)	(F =) 4.0×10^{-5} (N) The net force parallel to windscreen = 0 or F is equal to the parallel component (of the weight down the windscreen) or parallel forces must be equal and opposite or $F = 8.0 \times 10^{-5}$ sin30	B1 B1	Possible ecf from **(b)(i)** **Allow**: Total force down/up the windscreen/slope is zero **Not**: 'net force = 0' – this is an incomplete answer
			Total	**5**	

4 **(a)** Fig. 4.1 shows the path of a tennis ball after bouncing on the ground at **A** and hitting a vertical wall at **B**.

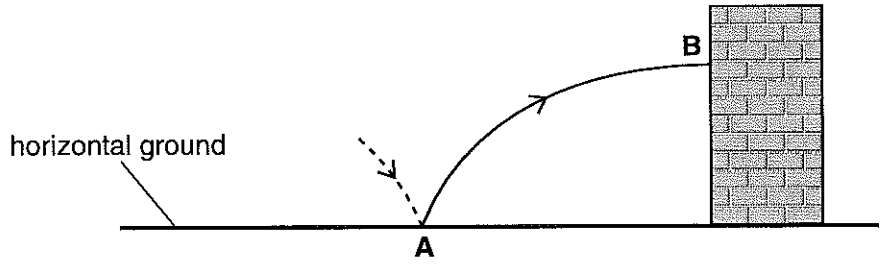


Fig. 4.1

The ball is travelling horizontally as it hits the wall at **B**. Air resistance has negligible effect on the motion of the ball.

(i) Explain why the horizontal component of the velocity of the ball remains constant as it moves from **A** to **B**.

.....

..... **[1]**

(ii) The ball loses some of its kinetic energy when it hits the wall at **B**. It leaves the wall horizontally.

1 On Fig. 4.1, sketch the path of the ball between bouncing at the wall and hitting the ground.

2 Explain how the time taken for the ball to travel from **A** to **B** compares with the time it takes to travel from **B** to the ground.

.....

.....

.....

[3]

(b) A student is given a metre rule, a stopwatch and a tennis ball.
Explain how this equipment can be used to determine an **approximate** value for the acceleration *g* of free fall.

.....

.....

.....

.....

.....

.....

..... **[3]**

(c) Fig. 4.2 shows a tennis ball moving up a smooth ramp at time $t = 0$.

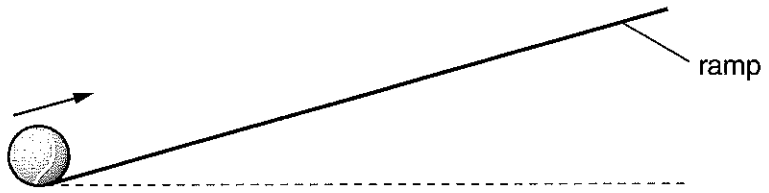


Fig. 4.2

Fig. 4.3 shows a graph of velocity v against time t for this ball.

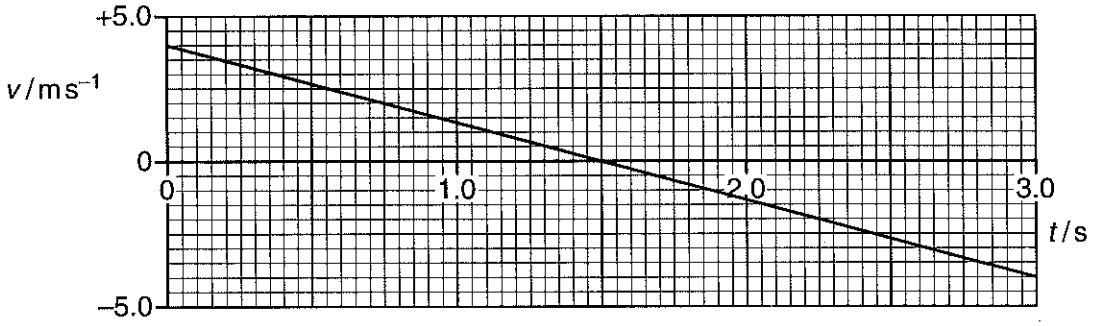


Fig. 4.3

(i) Describe, without calculation, the motion of the ball between $t = 0$ and $t = 3.0$ s.

.....

.....

.....

.....

..... **[3]**

(ii) Calculate the maximum distance D travelled by the ball up the ramp.

$D =$ ..... m **[2]**

[Total: 12]

Question			Answers	Marks	Guidance
4	(a)	(i)	There is only a vertical force / weight is vertical / no horizontal force(s) / acceleration is vertical	B1	**Not** 'horizontal acceleration is zero' -- since horizontal velocity is constant is given in the question
		(ii)	1 Correct sketch of the rebound path. 2 The time is the same. For both, the height / vertical distance and (vertical) acceleration are the same.	B1 M1 A1	**Note**: The ball must hit the ground closer to wall. The rebound path should be curved and below the original path. **Allow** $s = \frac{1}{2}at^2$ with s and a are the same (for both)
	(b)		Drop the ball from a given height **and** measure time of fall. $s = ut + \frac{1}{2}at^2$ **and** $u = 0$ or $s = \frac{1}{2}at^2$ (The acceleration of free fall is determined using) $a = 2s/t^2$	B1 B1 B1	 **Allow** $a \equiv g$ and $h \equiv s$ **Note:** a must be the subject to gain this B1 mark **Note:** $a = 2s/t^2$ will score the last two B1 marks **Allow** full credit for graphical approach: Drop ball from different heights & measure the times of fall (B1) ; plot a graph of s against t^2 (B1) ; $g = 2 \times$ gradient (B1)
	(c)	(i)	Constant deceleration or uniform deceleration or constant negative acceleration or constant rate (of change) of velocity (Momentarily) stops at 1.5 (s) or reaches maximum height at 1.5 (s) Clear idea of returning back. (AW)	B1 B1 B1	**Allow** constant / uniform acceleration / acceleration is 2.66.. (m s^{-2}) **Allow** 'constant rate of deceleration or acceleration' **Not** 'slowing down' **Allow**: (The ball) goes up and (then) down (the ramp) **Not**: velocity changes sign or direction changes
		(ii)	distance = $\frac{1}{2} \times 4.0 \times 1.5$ distance = 3.0 (m)	C1 A1	**Note**: Speed in range 3.0 to 5.0 (m s^{-1}) and $v \neq 4.0$ (m s^{-1}), then possible ecf **Allow** 1 sf answer **Allow** full credit for correct use of equation(s) of motion **Special case:** total distance travelled is calculated; allow 1 mark for an answer of 6.0 (m)
			Total	**12**	

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

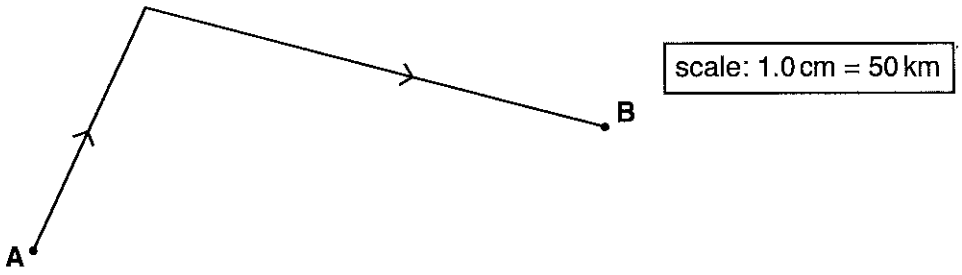


Fig. 3.1

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]**

Question			Answer	Marks	Guidance
3	a	i	Length from **A** to **B** = 8.0 (cm)	C1	**Allow** ± 0.1 cm
			displacement = 400 (km) or time = 1500 (s)		
			average velocity = $400 \times 10^3/1500$	C1	Possible ecf within the calculation for an incorrect value for length **AB**.
			average velocity = 270 (m s^{-1})	A1	**Note** no credit if distance is used.
		ii	(The average speed is different because) the <u>distance</u> (travelled) is different / not the same / greater than the <u>displacement</u>	B1	
	b	i	distance = $2 \times \pi \times 4.2 \times 10^8$	C1	
			speed = $\frac{2\times\pi\times4.2\times10^8}{1.5\times10^5}$		
			speed = 1.8×10^4 (m s^{-1})	A1	**Note**: Answer to 3 sf is 1.76×10^4 (m s^{-1}) **Not** 5600π (m s^{-1})
		ii	($0 = u^2 - 2as$)		
			$(1.3\times10^3)^2 = 2\times a\times470\times10^3$ (Any subject)	C1	**Allow** full credit for '$mgh = ½ mu^2$' approach **Ignore** signs
			$a = \frac{(1.3\times10^3)^2}{2\times470\times10^3}$ (a must be the subject)	C1	
			acceleration = 1.8 (m s^{-2})	A1	**Allow**: 2 marks for 1.8×10^n; $n \neq 0$
			Total	**9**	

2 **(a)** *Energy* and *work done* are scalar quantities and have the same unit as each other.

State **two** other scalar quantities in physics that have the same unit as each other.

.....

..... **[1]**

(b) Two forces **A** and **B** act through the same point in an object. These two forces are shown in Fig. 2.1. No other forces act on the object.

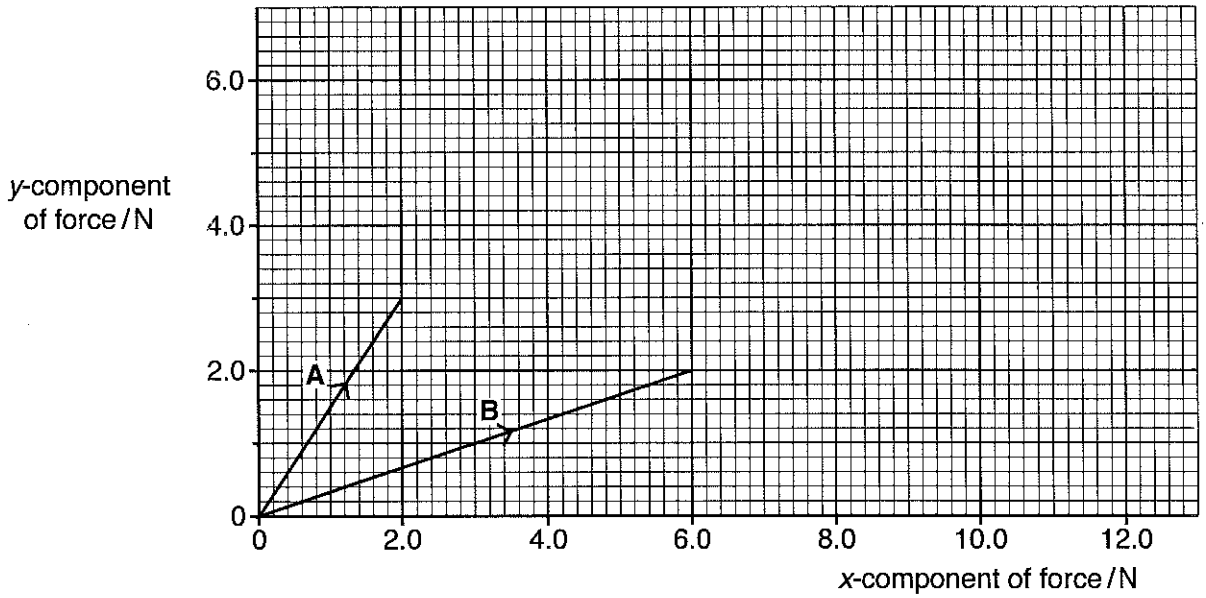


Fig. 2.1

(i) Use Fig. 2.1 to determine the *x*- and *y*- components of the force **B**.

x-component = ... N

y-component = ... N
[1]

(ii) Use Fig. 2.1 to determine the magnitude of the resultant of the two forces **A** and **B**.

resultant force = ... N **[3]**

(c) Fig. 2.2 shows a jet of water from the end of a hosepipe.

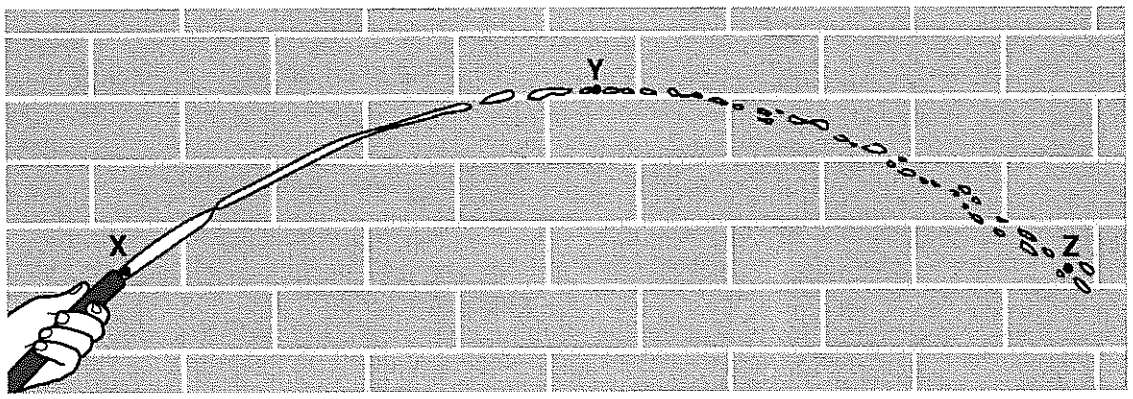


Fig. 2.2

Air resistance has negligible effect on the motion of the water jet. The water jet reaches maximum height at point **Y**.

(i) State the direction of the force acting on the water at **Y**.

.....[1]

(ii) Describe and explain how the horizontal component of the velocity of the water varies from point **X** to point **Y**.

.....

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.....

.....

.....[2]

(iii) Describe how the vertical component of the velocity of the water varies from point **X** to point **Z**.

.....

.....

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.....

.....

.....[2]

Question			Answer	Marks	Guidance
2	a		pressure and stress or pressure and Young modulus or stress and Young modulus or moment (of a force) and torque (of a couple)	B1	**Allow** other correct combinations **Allow** the following: • e.m.f. and p.d. • Any two from frequency, activity, decay constant and Hubble constant because of the s^{-1} **Ignore** any units given (even if incorrect) **Special case**: Allow quantities with no units, e.g. strain and efficiency. **Not** any combination of length, distance and extension
	b	i	*x*-component = 6.0 (N) and *y*-component = 2.0 (N)	B1	**Allow** 1 sf answers **Allow** tolerance ± 0.1 N **Not** *x*-component = 2.0 (N) and *y*-component = 6.0 (N)
		ii	resultant components are 8.0 (N) and 5.0 (N) $F^2 = 8.0^2 + 5.0^2$ force = 9.4 (N)	C1 C1 A1	**Allow**: 1 sf values for this C1 mark Possible ecf from **(b)(i)** with *x*-components = 2 + **b(i)** and *y*-component = 3 + **b(i)**. **Note**: Answer is 9.43 to 3sf **Not** an answer left in square root form, e.g $\sqrt{89}$ **Allow** full credit for a scale drawing; marks awarded as below: • A dot / cross / mark at 8.0,5.0 (± 0.1) C1 • Line drawn from 0,0 to 8.0,5.0 C1 • force = 9.4 ± 0.1 (N) A1
	c	i	Down	B1	**Allow** a downward arrow on Fig. 2.2

Question			Answer	Marks	Guidance
		ii	Horizontal component of the velocity is constant There is no <u>horizontal</u> <u>force</u>	B1 B1	**Allow**: There is no horizontal <u>acceleration</u> **Allow**: Weight / *g* has no horizontal component or Weight / *g* is 90° to the horizontal or Weight / *g* is vertical or 'there is <u>only</u> a vertical force' (**Not** 'gravity' for 'weight'; allow 'force of gravity')
		iii	Any <u>two</u> from: • It decreases from **X** to **Y** • It is zero at **Y** / It has the same magnitude at **X** and Z • It increases from **Y** to **Z** • It is positive from **X** to **Y** and negative from **Y** to **Z** (or vice versa)	B1 × 2	**Ignore** description in terms of acceleration or deceleration **Allow** it changes sign / direction from **X** to **Z**
			Total	**10**	