Q1. **(a)** The ampere, metre and second are SI base units.

State **two** other SI base units.

1. ....

2. ....
[2]

(b) The average drift speed v of electrons moving through a metal conductor is given by the equation:

$$v = \frac{\mu F}{e}$$

where e is the charge on an electron
F is a force acting on the electron
and μ is a constant.

Determine the SI base units of μ.

SI base units ....[3]

[Total: 5]

Q2. **(a)** A property of a vector quantity, that is not a property of a scalar quantity, is direction. For example, velocity has direction but speed does not.

(i) State **two** other scalar quantities and **two** other vector quantities.

scalar quantities: .... and ....

vector quantities: .... and ....

[2]

(ii) State **two** properties that are possessed by both scalar and vector physical quantities.

1. ....

2. ....

[2]

(b) A ship at sea is travelling with a velocity of $13\,\text{m s}^{-1}$ in a direction 35° east of north in still water, as shown in Fig. 1.1.

Fig. 1.1

(i) Determine the magnitudes of the components of the velocity of the ship in the north and the east directions.

north component of velocity = ... m s^{-1}

east component of velocity = ... m s^{-1}

[2]

(ii) The ship now experiences a tidal current. The water in the sea moves with a velocity of $2.7\,\text{m s}^{-1}$ to the west.

Calculate the resultant velocity component of the ship in the east direction.

Q3. **(a)** State what is meant by a *scalar* quantity and by a *vector* quantity.

scalar: ....

....

vector: ....

.... [2]

(b) Complete Fig. 1.1 to indicate whether each of the quantities is a vector or a scalar.

quantity	vector or scalar
power	
temperature	
momentum	

Fig. 1.1

[2]

(c) An aircraft is travelling in wind. Fig. 1.2 shows the velocities for the aircraft in still air and for the wind.

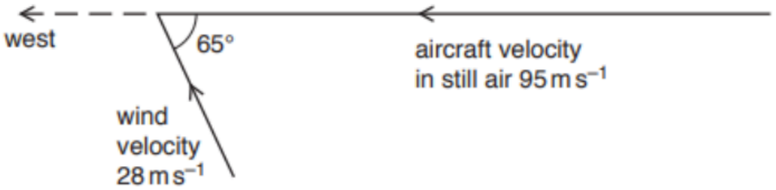

Fig. 1.2

The velocity of the aircraft in still air is 95 $m\,s^{-1}$ to the west.
The velocity of the wind is 28 $m\,s^{-1}$ from 65° south of east.

(i) On Fig. 1.2, draw an arrow, labelled R, in the direction of the resultant velocity of the aircraft. [1]

(ii) Determine the magnitude of the resultant velocity of the aircraft.

magnitude of velocity = ... $m s^{-1}$ [2]

[Total: 7]

Q4. **(a)** Two forces, with magnitudes 5.0 N and 12 N, act from the same point on an object. Calculate the magnitude of the resultant force R for the forces acting

(i) in opposite directions,

R = ... N [1]

(ii) at right angles to each other.

R = ... N [1]

(b) An object X rests on a smooth horizontal surface. Two horizontal forces act on X as shown in Fig. 1.1.

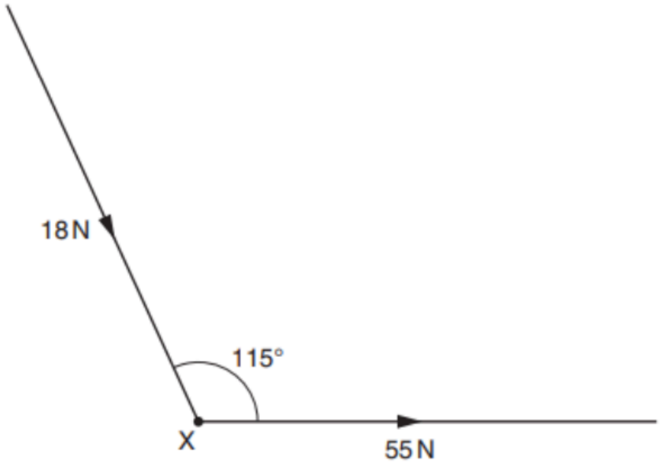

Fig. 1.1 (not to scale)

A force of 55 N is applied to the right. A force of 18 N is applied at an angle of 115° to the direction of the 55 N force.

Q5. **(a)** **(i)** Define *power*.

....

....[1]

(ii) Show that the SI base units of power are $kg\,m^2\,s^{-3}$.

[1]

(b) All bodies radiate energy. The power P radiated by a body is given by

$$P = kAT^4$$

where T is the thermodynamic temperature of the body,
A is the surface area of the body
and k is a constant.

(i) Determine the SI base units of k.

base units ....[2]

(ii) On Fig. 1.1, sketch the variation with T^2 of P. The quantity A remains constant.

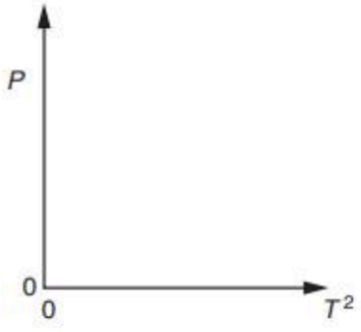

Fig. 1.1

[1]

[Total: 5]

Cyrus Ishaq

Q6. **(a)** The distance between the Sun and the Earth is 1.5×10^{11} m. State this distance in Gm.

distance = ... Gm [1]

(b) The distance from the centre of the Earth to a satellite above the equator is 42.3 Mm. The radius of the Earth is 6380 km.
A microwave signal is sent from a point on the Earth directly below the satellite.

Calculate the time taken for the microwave signal to travel to the satellite and back.

time = ... s [2]

(c) The speed v of a sound wave through a gas of density ρ and pressure P is given by

$$v = \sqrt{\frac{CP}{\rho}}$$

where C is a constant.

Show that C has no unit.

[3]

(d) Underline all the scalar quantities in the list below.

acceleration   energy   momentum   power   weight   [1]

(e) A boat travels across a river in which the water is moving at a speed of $1.8\,m\,s^{-1}$. The velocity vectors for the boat and the river water are shown to scale in Fig. 1.1.

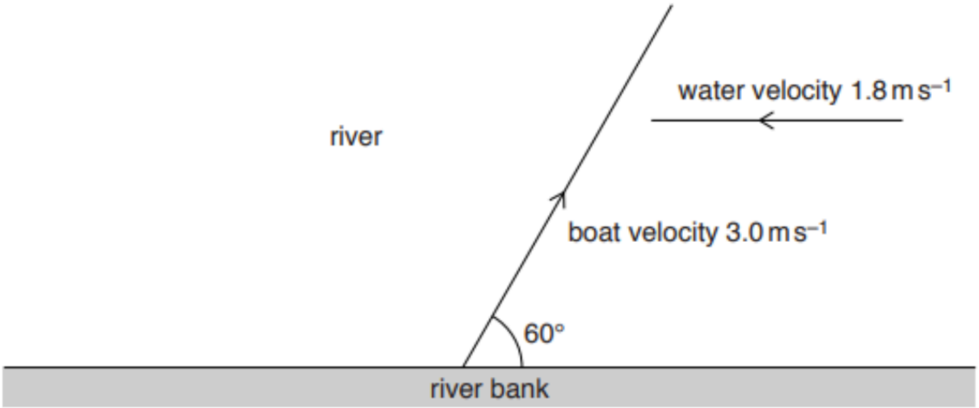

Fig. 1.1 (shown to scale)

In still water the speed of the boat is $3.0\,m\,s^{-1}$. The boat is directed at an angle of 60° to the river bank.

(i) On Fig. 1.1, draw a vector triangle or a scale diagram to show the resultant velocity of the boat. [2]

(ii) Determine the magnitude of the resultant velocity of the boat.

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

Q7. **(a)** The frequency of an X-ray wave is 4.6×10^{20} Hz.

Calculate the wavelength in pm.

wavelength = ... pm [3]

(b) The distance from Earth to a star is 8.5×10^{16} m. Calculate the time for light to travel from the star to Earth in Gs.

time = ... Gs [2]

(c) The following list contains scalar and vector quantities.

Underline **all** the scalar quantities.

acceleration   force   mass   power   temperature   weight   [1]

(d) A boat is travelling in a flowing river. Fig. 1.1 shows the velocity vectors for the boat and the river water.

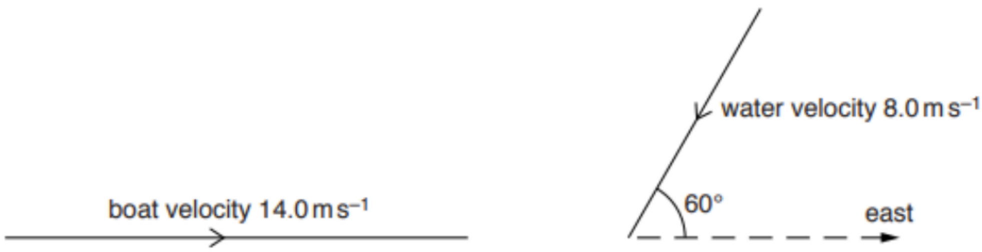

Fig. 1.1

The velocity of the boat in still water is $14.0\,\text{m}\,\text{s}^{-1}$ to the east. The velocity of the water is $8.0\,\text{m}\,\text{s}^{-1}$ from 60° north of east.

(i) On Fig. 1.1, draw an arrow to show the direction of the resultant velocity of the boat. [1]

(ii) Determine the magnitude of the resultant velocity of the boat.

magnitude of velocity = ... $m s^{-1}$ [2]

Q8. **(b)** An electromagnetic wave has frequency 12 THz.

(i) Calculate the wavelength in μm.

wavelength = ...μm [2]

(ii) State the name of the region of the electromagnetic spectrum for this frequency.

....[1]

(c) An object B is on a horizontal surface. Two forces act on B in this horizontal plane. A vector diagram for these forces is shown to scale in Fig. 1.1.

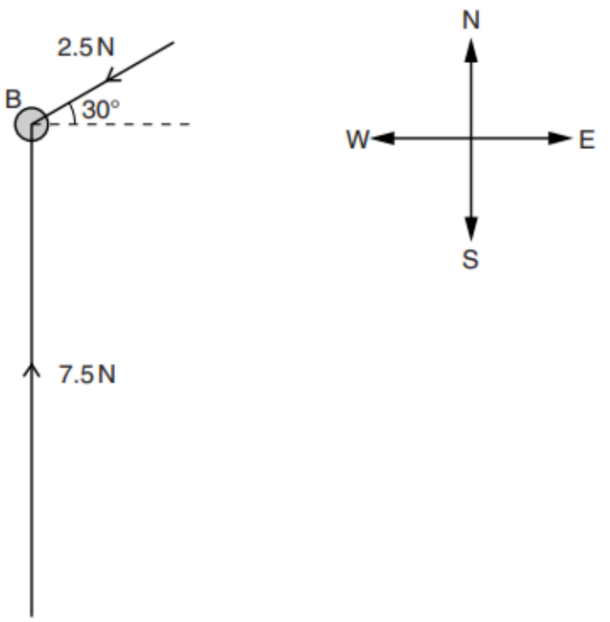

Fig. 1.1

A force of 7.5 N towards north and a force of 2.5 N from 30° north of east act on B. The mass of B is 750 g.

(i) On Fig. 1.1, draw an arrow to show the approximate direction of the resultant of these two forces. [1]

(ii) **1.** Show that the magnitude of the resultant force on B is 6.6 N.

[1]

2. Calculate the magnitude of the acceleration of B produced by this resultant force.

magnitude = ... $m s^{-2}$ [2]

(iii) Determine the angle between the direction of the acceleration and the direction of the 7.5 N force.

angle = ... ° [1]

Q9. **(a)** The spacing between two atoms in a crystal is 3.8×10^{-10} m. State this distance in pm.

spacing = ... pm [1]

(b) Calculate the time of one day in Ms.

time = ... Ms [1]

(c) The distance from the Earth to the Sun is 0.15 Tm. Calculate the time in minutes for light to travel from the Sun to the Earth.

time = ... min [2]

(d) Underline all the vector quantities in the list below.

distance energy momentum weight work [1]

(e) The velocity vector diagram for an aircraft heading due north is shown to scale in Fig. 1.1. There is a wind blowing from the north-west.

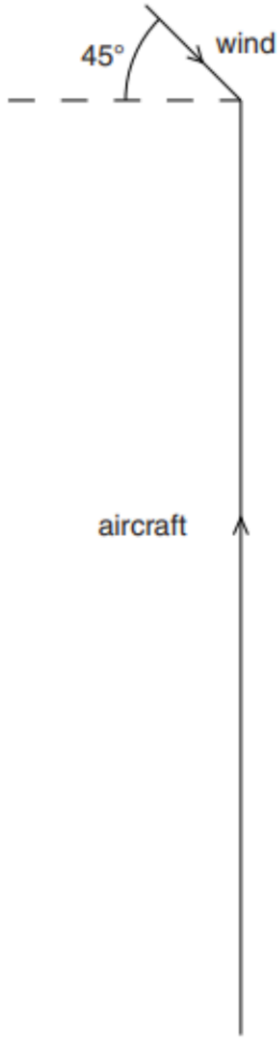

Fig. 1.1

The speed of the wind is $36\,m\,s^{-1}$ and the speed of the aircraft is $250\,m\,s^{-1}$.

(i) Draw an arrow on Fig. 1.1 to show the direction of the resultant velocity of the aircraft. [1]

(ii) Determine the magnitude of the resultant velocity of the aircraft.

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

Q10. **(a)** Distinguish between scalars and vectors.

....

....[1]

(b) Underline **all** the vector quantities in the list below.

acceleration   kinetic energy   momentum   power   weight   [2]

(c) A force of 7.5 N acts at 40° to the horizontal, as shown in Fig. 1.1.

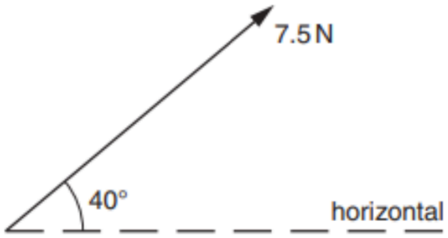

Fig. 1.1

Calculate the component of the force that acts

(i) horizontally,

horizontal component = ... N [1]

(ii) vertically.

vertical component = ... N [1]

(d) Two strings support a load of weight 7.5 N, as shown in Fig. 1.2.

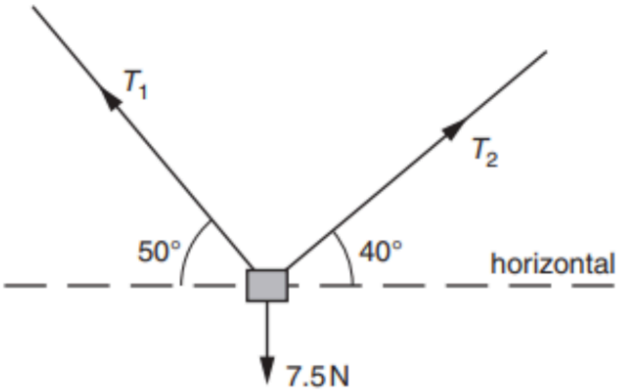

Fig. 1.2

One string has a tension T_1 and is at an angle 50° to the horizontal. The other string has a tension T_2 and is at an angle 40° to the horizontal. The object is in equilibrium. Determine the values of T_1 and T_2 by using a vector triangle or by resolving forces.

T_1 = ... N

T_2 = ... N
[4]

Q11. **(a)** **(i)** Distinguish between vector quantities and scalar quantities.

....

....

....[2]

(ii) State whether each of the following is a vector quantity or a scalar quantity.

1. temperature

....[1]

2. acceleration of free fall

....[1]

3. electrical resistance

....[1]

(b) A block of wood of weight 25 N is held stationary on a slope by means of a string, as shown in Fig. 1.1.

(i) Use the resolution of forces or a scale diagram to show that the magnitude of the resultant force acting on X is 65 N.

[2]

(ii) Determine the angle between the resultant force and the 55 N force.

angle = ... ° [2]

(c) A third force of 80 N is now applied to X in the opposite direction to the resultant force in **(b)**.

The mass of X is 2.7 kg.

Calculate the magnitude of the acceleration of X.

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

[Total: 9]

Q12. Make estimates of the following quantities.

(a) the thickness of a sheet of paper

thickness = ... mm [1]

(b) the time for sound to travel 100 m in air

time = ... s [1]

(c) the weight of 1000 cm^3 of water

weight = ... N [1]

Q13.

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

similarity: ....

....

difference: ....

....

[2]

(b) A student takes several measurements of the same quantity. This set of measurements has high precision, but low accuracy.

Describe what is meant by:

(i) *high precision*

....

.... [1]

(ii) *low accuracy*.

....

.... [1]

[Total: 4]

Mark scheme

Q1.

Question	Answer	Marks
1(a)	kilogram / kg	B1
	kelvin / K	B1
1(b)	units for *v*: m s^{-1} <u>and</u> units for *F*: kg m s^{-2}	C1
	units for *e*: A s	C1
	units for μ: m s^{-1} A s / kg m s^{-2} = A kg^{-1} s^2	A1

Q2.

Question	Answer	Marks
1(a)(i)	two correct scalar quantities e.g. time, mass, distance, temperature	B1
	two correct vector quantities e.g. force, acceleration, velocity, displacement	B1
1(a)(ii)	magnitude	B1
	unit	B1
1(b)(i)	north component of velocity = 11 m s^{-1}	A1
	east component of velocity = 7.5 m s^{-1}	A1
1(b)(ii)	velocity = 7.5 – 2.7 = 4.8 m s^{-1}	A1
1(b)(iii)	velocity = $\sqrt{(11^2 + 4.8^2)}$	C1
	= 12 m s^{-1}	A1
1(b)(iv)	angle = $\tan^{-1}$ (4.8 / 11)	C1
	= 24°	A1

Q3.

Question	Answer	Marks
1(a)	a scalar has magnitude (only)	B1
	a vector has magnitude and direction	B1
1(b)	power: scalar temperature: scalar momentum: vector *(two correct 1 mark, all three correct 2 marks)*	B2
1(c)(i)	arrow labelled R in a direction from 5° to 20° north of west	B1
1(c)(ii)	$v^2 = 28^2 + 95^2 - (2 \times 28 \times 95 \times \cos 115°)$ **or** $v^2 = [(95 + 28\cos 65°)^2 + (28\sin 65°)^2]$	C1
	v = 110 ms^{-1} (109.8 ms^{-1})	A1
	or (scale diagram method)	
	triangle of velocities drawn	(C1)
	v = 110 ms^{-1} (allow 108–112 m s^{-1})	(A1)

Q4.

Question	Answer	Marks
1(a)(i)	R = 7(.0) N	**B1**
1(a)(ii)	R = 13 N	**B1**
1(b)(i)	forces resolved: 18 sin 65° (vertical) **and** 55 + 18 cos 65° (horizontal) **or** scale drawing: correct triangle drawn for forces	**B1**
	$F = [(18 \sin 65°)^2 + (55 + 18 \cos 65°)^2]^{1/2}$ = 65 (64.7) N **or** scale drawing: scale given, length of resultant given correctly, ± 1 N	**A1**
1(b)(ii)	angle = $\tan^{-1}$ [18 sin 65° / (55 + 18 cos 65°)] = $\tan^{-1}$ (16.3 / 62.6) **or** scale drawing: correct angle measured/direction correct on diagram below the 55 N force	**C1**
	angle = 15 (14.6)° (below the 55 N force) **or** scale drawing: angle = 15° ± 1°	**A1**
1(c)	(resultant) force = mass × acceleration	**C1**
	80 – 65 = 2.7a	**C1**
	a = 5.6 m s^{-2} [5.7 if 64.7 N used from **(i)**]	**A1**

Q5.

Question	Answer	Marks
1(a)(i)	work (done) / time (taken) **or** energy (transferred) / time (taken)	**B1**
1(a)(ii)	Correct substitution of base units of all quantities into any correct equation for power. Examples: ($P = E / t$ or W / t gives) kg $m^2 s^{-2}$ / s = kg $m^2 s^{-3}$ ($P = Fs / t$ or mgh / t gives) kg m s^{-2} m / s = kg $m^2 s^{-3}$ ($P = ½mv^2 / t$ gives) kg (m $s^{-1})^2$ / s = kg $m^2 s^{-3}$ ($P = Fv$ gives) kg m s^{-2} m s^{-1} = kg $m^2 s^{-3}$ ($P = VI$ gives) kg $m^2 s^{-2} A^{-1} s^{-1}$ A = kg $m^2 s^{-3}$	**A1**
1(b)(i)	units of A: m^2 **and** units of T: K	**C1**
	units of k: kg $m^2 s^{-3}$ / $m^2 K^4$ = kg $s^{-3} K^{-4}$	**A1**
1(b)(ii)	curve from the origin with increasing gradient	**B1**

Q6.	**(a)** 150 or 1.5×10^2 Gm	A1	[1]
	(b) distance = $2 \times (42.3 - 6.38) \times 10^6$ (= 7.184×10^7 m)	C1	
	(time =) $7.184 \times 10^7 / (3.0 \times 10^8) = 0.24$ (0.239) s	A1	[2]
	(c) units of pressure P: $\text{kg m s}^{-2}/\text{m}^2 = \text{kg m}^{-1}\text{s}^{-2}$	M1	
	units of density ρ: kg m^{-3} and speed v: m s^{-1}	M1	
	simplification for units of C: $C = v^2\rho/P$ units: $(\text{m}^2\text{s}^{-2}\text{kg m}^{-3})/\text{kg m}^{-1}\text{s}^{-2}$ and cancelling to give no units for C	A1	[3]
	(d) energy and power *(both underlined and no others)*	A1	[1]
	(e) **(i)** vector triangle of correct orientation	M1	
	three arrows for the velocities in the correct directions	A1	[2]
	(ii) length measured from scale diagram 5.2 ± 0.2 cm or components of boat speed determined parallel and perpendicular to river flow	C1	
	velocity = 2.6 m s^{-1} (allow ± 0.1 m s^{-1})	A1	[2]
Q7.	**(a)** $v = f\lambda$	C1	
	$\lambda = (3.0 \times 10^8)/(4.6 \times 10^{20})$	C1	
	(= 6.52×10^{-13} =) 0.65(2) pm	A1	[3]
	(b) $t = (8.5 \times 10^{16})/(3.0 \times 10^8)$	C1	
	(= 2.83×10^8 =) 0.28(3) Gs	A1	[2]
	(c) mass, power and temperature all underlined and no others	B1	[1]
	(d) **(i)** arrow in the direction 30° to 40° south of east	B1	[1]
	(ii) triangle of velocities completed (i.e. correct scale diagram) or correct working given e.g. $[14^2 + 8.0^2 - 2(14)(8.0)\cos 60°]^{1/2}$ **or** $[(14 - 8.0\cos 60°)^2 + (8.0\sin 60°)^2]^{1/2}$	C1	
	resultant velocity = 12(.2) (or 12.0 to 12.4 from scale diagram) m s^{-1}	A1	[2]

Q8. **(b)** **(i)** wavelength = $3 \times 10^8 / 12 \times 10^{12}$ C1
= 25 μm A1 [2]

(ii) infra-red / IR B1 [1]

(c) **(i)** arrow drawn up to the left of 7.5 N force
approximately 5° to 40° to west of north A1 [1]

(ii) **1.** correct vector triangle or working to show
magnitude of resultant force = 6.6 N
allow 6.5 to 6.7 N if scale diagram M1 [1]

2. magnitude of acceleration = 6.6 / 0.75
[scale diagram: (6.5 to 6.7) / 0.75] C1

= 8.8 m s^{-2} [scale diagram: 8.7 – 8.9 m s^{-2}] A1 [2]

(iii) 19° [<u>use of scale diagram</u> allow 17° to 21° (a diagram must be seen)] B1 [1]

Q9. **(a)** spacing = 380 or 3.8×10^2 pm B1 [1]

(b) time = 24 × 3600
time = 0.086 (0.0864) Ms B1 [1]

(c) time = distance / speed = $\dfrac{1.5 \times 10^{11}}{3 \times 10^8}$ C1

= 500 (s) = 8.3 min A1 [2]

(d) momentum and weight B1 [1]

(e) **(i)** arrow to the right of plane direction (about 4° to 24°) B1 [1]

(ii) scale diagram drawn
or use of cosine formula $v^2 = 250^2 + 36^2 - 2 \times 250 \times 36 \times \cos 45°$
or resolving $v = [(36 \cos 45°)^2 + (250 - 36 \sin 45°)^2]^{1/2}$ C1

resultant velocity = 226 (220 – 240 for scale diagram) m s^{-1}
allow one mark for values 210 to 219 or 241 to 250 m s^{-1}
or use of formula (v^2 = 51068) v = 230 (226) m s^{-1} A1 [2]

Q10. **(a)** scalar has magnitude/size, vector has magnitude/size and direction B1 [1]

(b) acceleration, momentum, weight B2 [2]
(–1 for each addition or omission but stop at zero)

(c) **(i)** horizontally: $7.5\cos 40°$ / $7.5\sin 50°$ = 5.7(45) / 5.75 <u>not</u> 5.8 N A1 [1]

(ii) vertically: $7.5\sin 40°$ / $7.5\cos 50°$ = 4.8(2) N A1 [1]

(d) *either* correct shaped triangle M1
correct labelling of two forces, three arrows and two angles A1
or correct resolving: $T_2\cos 40° = T_1\cos 50°$ (B1)
$T_1\sin 50° + T_2\sin 40° = 7.5$ (B1)
T_1 = 5.7(45) (N) A1
T_2 = 4.8 (N) A1 [4]
(allow ± 0.2 N for scale diagram)

Q11. **(a)** **(i)** scalar quantity has magnitude (allow size) B1
vector quantity has magnitude and direction B1 [2]

(ii) **1.** temperature: scalar B1 [1]
2. acceleration: vector B1 [1]
3. resistance: scalar B1 [1]

(b) *either* triangle / parallelogram with correct shape C1
tension = 14 .3 N *(allow ± 0.5 N)* A2 [3]

(if > ±0.5 N but ≤ ±1 N, allow 1 mark)
or $R = 25\cos 35°$ (C1)
$T = R\tan 35°$ (C1)
T = 14.3 N (A1)
or $T = 25\sin 35°$ (C2)
T = 14.3 N (A1)
or R and T resolved vertically and horizontally (C2)
leading to T = 14.3 N (A1)

Q12.
(a) allow 0.05 mm → 0.15 mm B1 [1]

(b) allow 0.25 s → 0.5 s B1 [1]

(c) allow 8 N → 12 N B1 [1]

ignore number of significant figures

Q13.

Question	Answer	Marks
1(a)	similarity: both have magnitude	**B1**
	difference: distance is a scalar/does not have direction **or** displacement is a vector/has direction	**B1**
1(b)(i)	the measurements have a small range	**B1**
1(b)(ii)	the (average of the) measurements is not close to the true value	**B1**