Past-paper walk-through

Scalars and vectors ▪ 1.4

eXercise

Questions in this set

- 9702/11 N25 Q1 ▪ 1 mark
- 9702/11 N25 Q4 ▪ 1 mark
- 9702/24 N25 Q1 ▪ 11 marks
- 9702/11 J25 Q1 ▪ 1 mark
- 9702/11 J25 Q4 ▪ 1 mark
- 9702/14 J25 Q4 ▪ 1 mark
- 9702/22 J25 Q1 ▪ 10 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 1

9702/11 N25 ▪ Q1 ▪ 1 mark

1 The table shows some physical quantities.

Which row correctly identifies the quantities as scalars or vectors?

	acceleration	charge	kinetic energy	wavelength
A	scalar	vector	vector	scalar
B	vector	vector	scalar	scalar
C	scalar	scalar	scalar	vector
D	vector	scalar	scalar	scalar

Solution 1

Answer: **D**

Why

- Acceleration is the only vector here – it is a rate of change of velocity.
- Charge, kinetic energy and wavelength are all scalars.
- Charge can be negative, but a sign is not a direction in space.

Question 4

9702/11 N25 ▪ Q4 ▪ 1 mark

The diagram shows two forces of 6.0 N acting on an object. The angle between the lines of action of the two forces is $60°$.

What is the magnitude of the resultant force? **[1]**

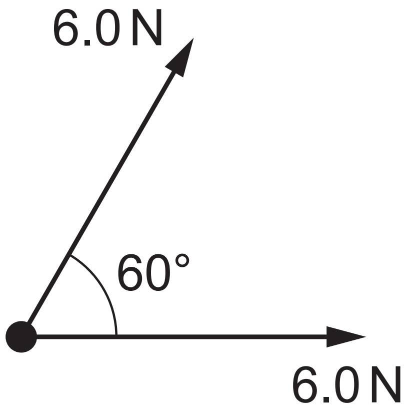
A 6.0 N

B 7.9 N

C 10 N

D 12 N

Question 4



Solution 4

- **A** 6.0 N
- **B** 7.9 N
- **C** 10 N ✓
- **D** 12 N

Why

- Two equal forces give a resultant along the bisector of the angle between them.
- $R = 2F\cos(\theta/2) = 2 \times 6.0 \times \cos 30^\circ = 10.4$ N.
- D would need the forces parallel; A would need 120° between them.

Question 1

9702/24 N25 ▪ Q1 ▪ 11 marks

A child kicks a ball so that it leaves horizontal ground with a velocity of 28 m s^{-1} at an angle of $34°$ to the horizontal, as shown in Fig. 1.1.

(a)(i) Calculate the horizontal component v_H and the vertical component v_V of the velocity of the ball immediately after it has left the ground. **[2]**

(a)(ii) Show that the ball reaches its maximum height at time $t = 1.6$ s. **[1]**

(a)(iii) On Fig. 1.2, sketch the variation of v_H with time t between $t = 0$ and $t = 3.2$ s. Label your line H. **[1]**

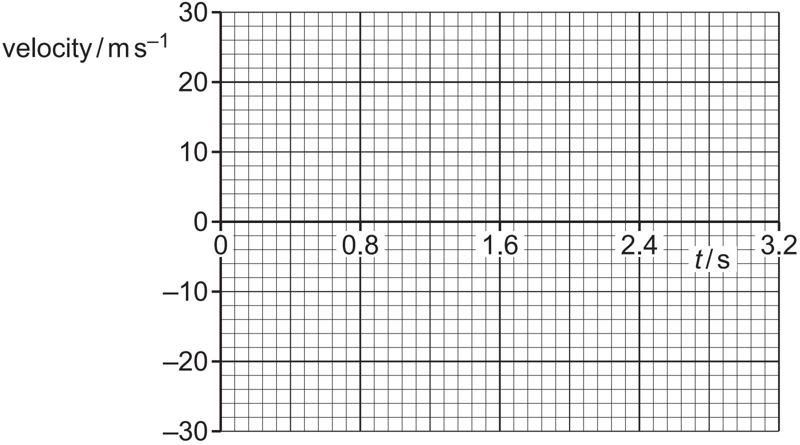
(a)(iv) On Fig. 1.2, sketch the variation of v_V with time t between $t = 0$ and $t = 3.2$ s. Assume that velocity in the upward direction is positive. Label your line V. **[3]**

(b)(i) Define momentum. **[1]**

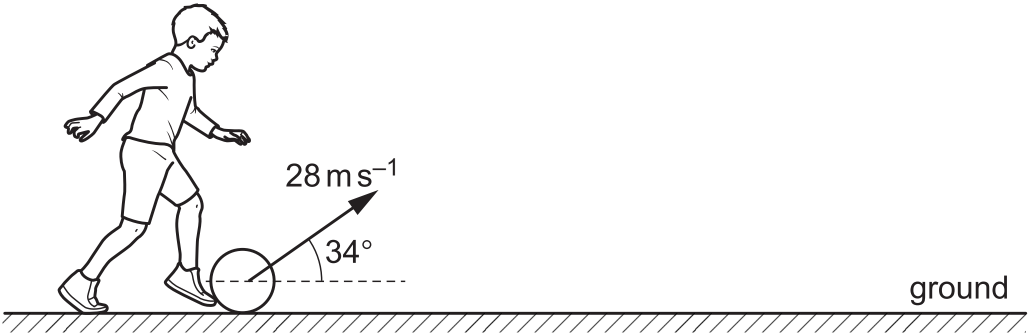
(b)(ii) Calculate the force that acts on the ball while it is in the air. **[2]**

(b)(iii) Determine the mass of the ball. **[1]**

Question 1



Question 1



Solution 1

(a)(i)

Worked steps

Resolve the launch velocity into two independent components.

- Horizontal: $v_H = v\cos\theta = 28 \times \cos 34° = 23$ m s^{-1}
- Vertical: $v_V = v\sin\theta = 28 \times \sin 34° = 16$ m s^{-1}

Check the sizes against the picture: the launch is nearer the ground than the vertical, so the horizontal component must be the larger one.

Mark scheme

- vH $= 28 \times$ cos 34°
- $=$ 23 m s–1 **A1**
- vV $= 28 \times$ sin 34°
- $=$ 16 m s–1 **A1**

Solution 1

(a)(ii) Worked steps

At maximum height the **vertical** velocity is momentarily zero; the horizontal one never changes and tells you nothing here.

- $v = u + at$ with $v = 0$, $u = 16\ \text{m s}^{-1}$, $a = -9.81\ \text{m s}^{-2}$
- $t = \dfrac{u}{g} = \dfrac{16}{9.81} = 1.6$ s, as required.

Solution 1

Mark scheme

- time $= 16 \,/\, 9.81 = 1.6$ s **A1**

Solution 1

(a)(iii)

Worked steps

Nothing acts horizontally (air resistance is ignored), so v_H never changes.

- Draw a **horizontal straight line** at $v = 23$ m s^{-1}, from $t = 0$ to $t = 3.2$ s.
- Label it **H**.

Mark scheme

- horizontal straight line at v = 23 m s–1 from t = 0 to t = 3.2 s **B1**

Solution 1

(a)(iv) Worked steps

Gravity is constant and downwards, so v_y falls at a steady rate: a straight line of gradient -9.81 m s^{-2}.

- Start at $v = +16$ m s^{-1} at $t = 0$.
- Cross the time axis at $t = 1.6$ s (the top of the flight, from part (a)(ii)).
- End at $v = -16$ m s^{-1} at $t = 3.2$ s — the same speed downwards as it left, because it lands at the height it started.
- Label it **V**.

Solution 1

Mark scheme

- straight diagonal line starting at a positive velocity from $t = 0$ to $t = 3.2$ s, crossing the time axis **B1**
- line starting at $v = 16$ m s–1 and ending at $v = –16$ m s–1 **B1**
- line passing through $v = 0$ at $t = 1.6$ s **B1**

Solution 1

(b)(i)

Mark scheme

- product of mass and velocity **B1**

Solution 1

(b)(ii)

Worked steps

Force is the rate of change of momentum, and the change of momentum is given.

- $F = \dfrac{\Delta p}{\Delta t} = \dfrac{13}{3.2}$
- $F = 4.1$ N

Mark scheme

- F = Δp / t **C1**
- = 13 / 3.2
- = 4.1 N **A1**

Solution 1

(b)(iii) Worked steps

Only weight acts on the ball in flight, so the force you just found **is** its weight.

- $m = \dfrac{F}{g} = \dfrac{4.1}{9.81} = 0.41$ kg
- Or from momentum: the vertical velocity reverses from $+16$ to -16 m s^{-1}, so $\Delta p = m(2 \times 16)$, giving $m = \dfrac{13}{32} = 0.41$ kg.

Solution 1

Mark scheme

- $m = \Delta p \,/\, v$
- $= 13 \,/\, (2 \times 16)$
- $= 0.41$ kg or $m = F \,/\, g$
- $= 4.06 \,/\, 9.81$
- $= 0.41$ kg **A1**

Question 1

9702/11 J25 ▪ Q1 ▪ 1 mark

Which quantity is a vector? **[1]**

A pressure

B temperature

C weight

D work

Solution 1

- **A** pressure
- **B** temperature
- **C** weight ✓
- **D** work

Why

- Weight is a force, and every force has a direction as well as a size.
- Pressure, temperature and work are all scalars.
- Work is a product of two vectors that yields a scalar, so it has no direction of its own.

Question 4

9702/11 J25 ▪ Q4 ▪ 1 mark

Two vectors, X and Y, are shown.

What are the directions of $X + Y$ and $X - Y$? **[1]**

A $X + Y$: $\rightarrow$ \quad $X - Y$: $\downarrow$

B $X + Y$: $\rightarrow$ \quad $X - Y$: $\uparrow$

C $X + Y$: $\leftarrow$ \quad $X - Y$: $\downarrow$

D $X + Y$: $\leftarrow$ \quad $X - Y$: $\uparrow$

Question 4

Solution 4

- **A** $X + Y$: $\rightarrow$ \quad $X - Y$: $\downarrow$
- **B** $X + Y$: $\rightarrow$ \quad $X - Y$: $\uparrow$ ✓
- **C** $X + Y$: $\leftarrow$ \quad $X - Y$: $\downarrow$
- **D** $X + Y$: $\leftarrow$ \quad $X - Y$: $\uparrow$

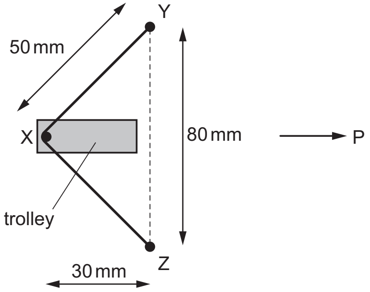
Why

- X points up and to the right, Y down and to the right, at equal angles.
- In X + Y the vertical parts cancel and the horizontal parts add, so it points to the right.
- −Y points up and to the left, so in X − Y the horizontal parts cancel and X − Y points up.

Question 4

9702/14 J25 ▪ Q4 ▪ 1 mark

4 The diagram shows two fixed pins, Y and Z. A length of elastic is stretched between Y and Z and around pin X, which is attached to a trolley.



Question 4

X is at the centre of the elastic and the trolley is to be propelled in the direction P at right angles to YZ. The tension in the elastic is 4.0 N.

What is the force accelerating the trolley in the direction P when the trolley is released?

A 2.4 N **B** 3.2 N **C** 4.8 N **D** 6.4 N

Solution 4

Answer: **C**

Why

- X sits 30 mm from YZ, because $\sqrt{50^2 - 40^2} = 30$ mm.
- Each half of the elastic pulls along its own 50 mm length, so its component along P is $4.0 \times 30/50 = 2.4$ N.
- Both halves pull the same way along P, so the total is $2 \times 2.4 = 4.8$ N.

Question 1

9702/22 J25 ▪ Q1 ▪ 10 marks

(a) Table 1.1 lists some physical quantities. Identify with ticks (✓) which quantities are vectors and which are scalars.

Table 1.1

quantity	scalar	vector
acceleration		
displacement		
gravitational potential energy		
speed		
temperature		

Question 1

[2]

Question 1

quantity	scalar	vector
acceleration		
displacement		
gravitational potential energy		
speed		
temperature		

Question 1

9702/22 J25 ▪ Q1 ▪ 10 marks

(b)(i) Using the concept of work done on the car, show that the kinetic energy E_K of the car is given by the equation

$$E_K = \frac{1}{2}mv^2$$

[3]

(b)(ii) The mass of the car is 920 kg. At time $t = 0$, the car is at rest. At time $t = 5.8$ s, its velocity is $17\ \mathrm{m\,s^{-1}}$.

Calculate the kinetic energy of the car at time $t = 5.8$ s. **[1]**

(b)(iii) Between time $t = 0$ and time $t = 5.8$ s, the work done against resistive forces is 4.7×10^4 J.

Determine the average output power of the car during this time. **[3]**

Question 1

(b)(iv) At time $t = 5.8$ s, the speed of the car becomes constant.
State and explain whether the output power of the car is greater than, less than or the same as the output power just before $t = 5.8$ s. **[1]**

Solution 1

(a)

Mark scheme

- acceleration and displacement identified as vectors (and no others) **B1**
- speed, temperature and gravitational potential energy identified as scalars (and no others) **B1**

Solution 1

(b)(i) Worked steps

"Using the concept of work done" fixes the starting point: begin at $W = Fs$ and eliminate everything the answer does not contain.

- Work done on the car: $W = Fs$, and by Newton's second law $F = ma$, so $W = mas$.
- The car starts from rest, so $v^2 = u^2 + 2as$ gives $v^2 = 2as$, i.e. $as = \dfrac{v^2}{2}$.
- Substitute: $W = m \times \dfrac{v^2}{2} = \frac{1}{2}mv^2$.
- All that work becomes kinetic energy, so $E_K = \frac{1}{2}mv^2$.

Solution 1

Mark scheme

- $W = Fs$ or $W = mas$ **B1**
- $s = v2 / 2a$ or $a = v2 / 2s$ or $as = v2 / 2$ **B1**
- $W = ma(v2 / 2a)$ or $W = m(v2 / 2s)s$ or $W = m(v2 / 2)$ and (so EK)= ½mv2 **B1**
- OR
- $W = Fs$ or $W = mas$
- (B1)
- $F = mv / t$ and $s = ½vt$

Solution 1

- (B1)
- $W = mv / t \times ½vt$ and (so E_K)$= ½mv^2$
- (B1)
- OR
- $W = Fs$ or $W = mas$
- (B1) $a = v / t$ and $s = ½vt$
- (B1)
- $W = m(v / t)(½vt)$ and (so E_K)$= ½mv^2$
- (B1)
- OR

Solution 1

- $W = Fs$ or $W = mas$
- (B1) $a = v / t$ and $s = ½at2$
- (B1)
- $W = m(v / t)(½ \times (v / t) \times t2)$ and (so EK)$= ½mv\ 2$
- (B1)

Solution 1

(b)(ii)

Worked steps

- $E_K = \frac{1}{2}mv^2 = \frac{1}{2} \times 920 \times 17^2$
- $E_K = 1.3 \times 10^5$ J

Mark scheme

- kinetic energy = ½ mv2
- = ½ × 920 × 172
- = 1.3 × 105 J **A1**

Solution 1

(b)(iii) Worked steps

The **output** power covers everything the engine did: the kinetic energy gained **and** the work done against resistance.

- Total work $= 1.3 \times 10^5 + 4.7 \times 10^4 = 1.8 \times 10^5$ J
- $P = \dfrac{W}{t} = \dfrac{1.8 \times 10^5}{5.8}$
- $P = 3.1 \times 10^4$ W

Solution 1

Mark scheme

- $P = W / t$ **C1**
- $= (4.7 \times 104 + 1.3 \times 105) / 5.8$ **C1**
- $= 3.1 \times 104$ W **A1**

Solution 1

(b)(iv)

Mark scheme

- (at/after $t = 5.8$ s) the kinetic energy (of the car) does not change / work is done only against resistive forces / no work is done to accelerate (the car) so (power output is) less **B1**