Past-paper walk-through

SI units ▪ 1.2

eXercise

Questions in this set

- 9702/11 N25 Q3 ▪ 1 mark
- 9702/11 N25 Q22 ▪ 1 mark
- 9702/12 N25 Q3 ▪ 1 mark
- 9702/22 N25 Q1 ▪ 11 marks
- 9702/12 J25 Q2 ▪ 1 mark
- 9702/12 J25 Q4 ▪ 1 mark

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 3

9702/11 N25 ▪ Q3 ▪ 1 mark

What are the SI base units of the watt? **[1]**

A $\mathrm{J\,s^{-1}}$

B $\mathrm{kg\,m^{2}\,s^{-3}}$

C $\mathrm{kg\,m^{2}\,s^{-1}}$

D $\mathrm{N\,m\,s^{-1}}$

Solution 3

A $\mathrm{J\,s^{-1}}$

B $\mathrm{kg\,m^2\,s^{-3}}$ ✓

C $\mathrm{kg\,m^2\,s^{-1}}$

D $\mathrm{N\,m\,s^{-1}}$

Why

- $1\ \mathrm{W} = 1\ \mathrm{J\ s^{-1}}$, and $1\ \mathrm{J} = 1\ \mathrm{N\ m} = \mathrm{kg\ m^2\ s^{-2}}$.
- Dividing by the second gives $\mathrm{kg\ m^2\ s^{-3}}$.
- A and D are correct units for power, but they are derived units, not base units.

Question 22

9702/11 N25 ▪ Q22 ▪ 1 mark

What are the SI base units of stress? **[1]**

A $\mathrm{kg\,m\,s^{-2}}$

B $\mathrm{kg\,m^{-1}\,s^{-2}}$

C $\mathrm{kg\,m^{-2}\,s^{-2}}$

D $\mathrm{kg\,m^{-3}\,s^{-2}}$

Solution 22

A $\mathrm{kg\,m\,s^{-2}}$

B $\mathrm{kg\,m^{-1}\,s^{-2}}$ ✓

C $\mathrm{kg\,m^{-2}\,s^{-2}}$

D $\mathrm{kg\,m^{-3}\,s^{-2}}$

Why

- Stress is force divided by area, so its unit is N m^{-2}.
- In base units 1 N $=$ kg m s^{-2}, so N m^{-2} $=$ kg m s^{-2} m^{-2}.
- Combining the metres leaves kg m^{-1} s^{-2}.

Question 3

9702/12 N25 ▪ Q3 ▪ 1 mark

Which physical quantity could have units of N $s^2 m^{-1}$? **[1]**

A acceleration

B force

C mass

D momentum

Solution 3

- **A** acceleration
- **B** force
- **C** mass ✓
- **D** momentum

Why

- Write the newton in base units: $\mathrm{N} = \mathrm{kg\ m\ s^{-2}}$.
- Then $\mathrm{N\ s^2\ m^{-1}} = \mathrm{kg\ m\ s^{-2}} \times \mathrm{s^2} \times \mathrm{m^{-1}}$.
- Every metre and second cancels, leaving kg – a mass.

Question 1

9702/22 N25 ▪ Q1 ▪ 11 marks

Scientists are investigating the variation in air pressure at different locations on a mountain.

(a) The scientists take measurements of several physical quantities at each location.

Complete Table 1.1 by stating the SI base unit for each quantity and identifying with a tick (✓) whether each quantity is a scalar or a vector. Use the space for any working.

Table 1.1

quantity measured	SI base unit	scalar	vector
air temperature			
air pressure			

Question 1

[2]

Question 1

quantity measured	SI base unit	scalar	vector
air temperature			
air pressure			

[2]

Question 1

measured quantity	percentage uncertainty
k	5%
F	3%
v	4%

Question 1

9702/22 N25 ▪ Q1 ▪ 11 marks

Scientists are investigating the variation in air pressure at different locations on a mountain.

(b)(i) Calculate the upthrust acting on the balloon when it is released. **[2]**

(b)(ii) Explain why an upthrust acts on the balloon. **[2]**

(b)(iii) The balloon has weight 19 N.

Calculate the magnitude of the initial acceleration of the balloon. **[3]**

Question 1

9702/22 N25 ▪ Q1 ▪ 11 marks

Scientists are investigating the variation in air pressure at different locations on a mountain.

(c) A quantity c relating to the motion of the balloon is calculated from three measured quantities k, F and v using the formula

$$c = \frac{2kF}{v^2}$$

The percentage uncertainties in the measured quantities are given in Table 1.2.

Table 1.2

measured quantity	percentage uncertainty
k	5%
F	3%
v	4%

Question 1

The calculated value of c is 1.8.
Determine the absolute uncertainty in c. **[2]**

Solution 1

(a)

Mark scheme

- air temperature: K and air pressure: kg m–1 s–2 **B1**
- scalar only ticked for both air temperature and air pressure **B1**

Solution 1

(b)(i) Worked steps

Upthrust is the weight of the air the balloon displaces, and the balloon is a sphere.

- $V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(0.903)^3 = 3.08\ \mathrm{m}^3$
- $U = \rho_{\mathrm{air}} V g = 1.1 \times 3.08 \times 9.81$
- $U = 33\ \mathrm{N}$

Solution 1

Mark scheme

- upthrust $= 1.1 \times 9.81 \times (4\pi \times 0.903\ /\ 3)$ **C1**
- $= 33$ N **A1**

Solution 1

(b)(ii)

Mark scheme

- (due to difference in height / depth there is a) difference in pressure between top and bottom (of balloon) **B1**
- (due to pressure difference, upwards) force on bottom of balloon is greater
- (than downwards force on top of balloon, so resultant force is upwards) **B1**

Solution 1

(b)(iii) Worked steps

Two steps, and the second is the one people forget: the mass comes from the **weight**, not from the volume.

- Resultant force $= U - W = 33 - 19 = 14$ N, upwards.
- Mass $= \dfrac{W}{g} = \dfrac{19}{9.81} = 1.94$ kg
- $a = \dfrac{F}{m} = \dfrac{14}{1.94}$
- $a = 7.2$ m s^{-2}, upwards.

Solution 1

Mark scheme

- $(\Sigma)F = 33 – 19$
- $(= 14\ N)$ **C1**
- $m = 19\ /\ 9.81$
- $(= 1.94\ kg)$ **C1**
- $a = (33 – 19)\ /\ (19\ /\ 9.81)$
- $= 7.2\ m\ s–2$ **A1**

Solution 1

(c) Worked steps

For a formula built only of products and quotients, **add** the percentage uncertainties — and a squared quantity counts twice. The 2 is exact and contributes nothing.

- $\dfrac{\Delta c}{c} = \dfrac{\Delta k}{k} + \dfrac{\Delta F}{F} + 2\dfrac{\Delta v}{v}$
- $= 5\% + 3\% + (2 \times 4\%) = 16\%$
- Absolute uncertainty $= 0.16 \times 1.8$
- $\Delta c = 0.29$ (or 0.3 to one significant figure, which is how an uncertainty is normally quoted).

Solution 1

Mark scheme

- $5 + 3 + (2 \times 4)$
- $(= 16\%)$ **C1**
- absolute uncertainty in c $= 1.8 \times 0.16$
- $= (\pm)\ 0.3$ **A1**

Question 2

9702/12 J25 ▪ Q2 ▪ 1 mark

What is $0.25\ \mathrm{kN\,mm^{-2}}$ expressed in $\mathrm{N\,m^{-2}}$? **[1]**

A $0.00025\ \mathrm{N\,m^{-2}}$

B $0.25\ \mathrm{N\,m^{-2}}$

C $250\,000\ \mathrm{N\,m^{-2}}$

D $250\,000\,000\ \mathrm{N\,m^{-2}}$

Solution 2

A $0.00025\ \mathrm{N\,m^{-2}}$

B $0.25\ \mathrm{N\,m^{-2}}$

C $250\,000\ \mathrm{N\,m^{-2}}$

D $250\,000\,000\ \mathrm{N\,m^{-2}}$ ✓

Why

- First the force: 0.25 kN $= 250$ N.
- Then the area: 1 m$^2 = 10^6$ mm^2, so 1 mm$^{-2} = 10^6$ m^{-2}.
- $250 \times 10^6 = 2.5 \times 10^8$ N m^{-2}, which is 250 000 000.

Question 4

9702/12 J25 ▪ Q4 ▪ 1 mark

The time period T of a pendulum is given by

$$T = 2\pi \left(\frac{L}{g}\right)^n$$

where L is the length of the pendulum and g is the acceleration of free fall.

The equation is homogeneous.

What is the value of n? **[1]**

A -2

B $-\frac{1}{2}$

C $\frac{1}{2}$

Question 4

D 2

Solution 4

A -2

B $-\frac{1}{2}$

C $\frac{1}{2}$ ✓

D 2

Why

- The pendulum equation is $T = 2\pi(L/g)^n$, and L/g has units of s^2.
- For the left-hand side to be a time, $(\mathrm{s}^2)^n = \mathrm{s}$, so $n = \frac{1}{2}$.
- A negative n would make a longer pendulum swing faster, which is not what happens.