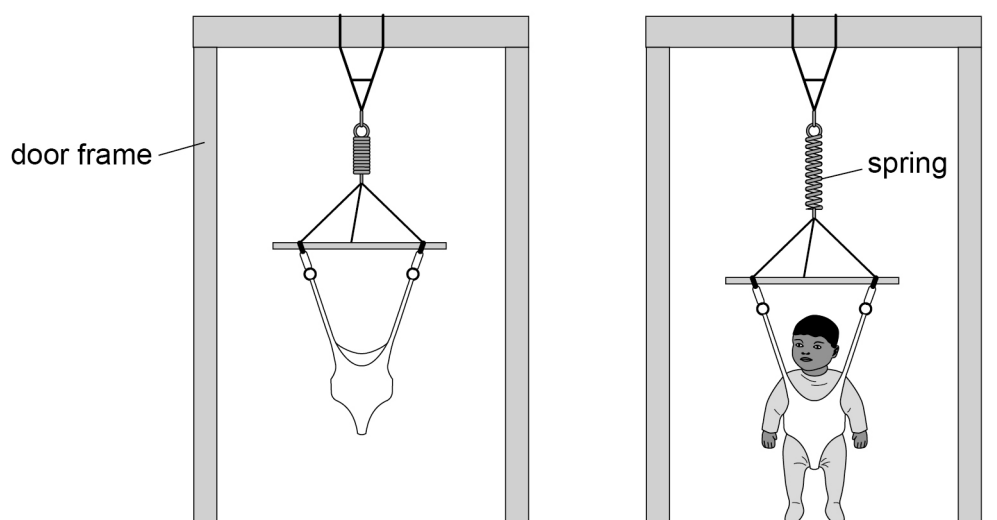**0 6** A baby bouncer consists of an inextensible harness attached to a spring.

door frame

spring

The stiffness of the spring is in the range:

[1 mark]

A 1–10 N m^{-1}

B 10–100 N m^{-1}

C 100–1000 N m^{-1}

D 1000–10 000 N m^{-1}

0 7 Which row only contains SI fundamental base units?

[1 mark]

A A, kg, N, s

B A, K, mol, s

C C, kg, m, mol
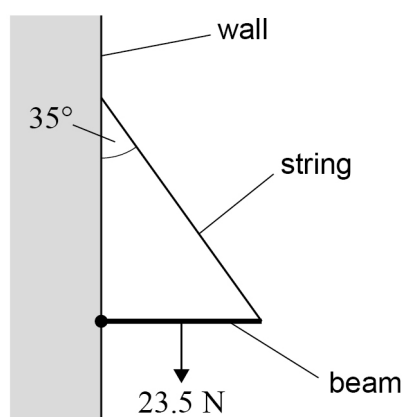
D J, K, m, s

Turn over ▶

Do not write outside the box

2 1 Which is a scalar quantity?

[1 mark]

A force ⬭

B kinetic energy ⬭

C momentum ⬭

D velocity ⬭

2 2 A uniform beam of weight 23.5 N is attached by a hinge to a vertical wall and supported by a string.
The string makes an angle of 35° to the wall.

What is the tension in the string?

[1 mark]

A 14 N ⬭

B 21 N ⬭

C 29 N ⬭

D 41 N ⬭

2 3 Which description of a couple and its unit is correct?

[1 mark]

	Description	Unit	
A	consists of two equal parallel forces	$N\ m^{-1}$	⬭
B	produces translational motion	$N\ m$	⬭
C	consists of two equal and opposite forces	$N\ m$	⬭
D	produces rotational motion	$N\ m^{-1}$	⬭

2 4 **P** and **Q** are two balls of the same diameter. **P** has a greater mass than **Q**.

Both balls are projected at the same time from the top of a tall building that stands on horizontal ground.
Both balls are projected with the same horizontal velocity.
P reaches the ground after time t_P and at a horizontal distance d_P from the building.
Q reaches the ground after time t_Q and at a horizontal distance d_Q from the building.

The air is still and air resistance is **not** negligible.

Which row is correct?

[1 mark]

	Time	Horizontal distance	
A	$t_P = t_Q$	$d_P = d_Q$	⬭
B	$t_P = t_Q$	$d_P > d_Q$	⬭
C	$t_P < t_Q$	$d_P = d_Q$	⬭
D	$t_P < t_Q$	$d_P > d_Q$	⬭

Turn over ▶

Do not write outside the box

2 5 A firework rocket moves vertically upwards.
The rocket's fuel burns at a steady rate to produce a constant thrust.
The mass of the rocket decreases with time.

Ignore the effects of air resistance on the rocket.

Which row shows the acceleration of the rocket before, and the acceleration immediately after, the fuel has been used up?

[1 mark]

	Acceleration before	**Acceleration immediately after**	
A	increasing upwards	constant downwards	⬯
B	increasing upwards	decreasing upwards	⬯
C	constant upwards	constant downwards	⬯
D	decreasing upwards	constant downwards	⬯

2 6 Object **P** has a mass of 7500 kg and travels at 12 m s^{-1}.
Object **Q** has a mass of 2500 kg and travels at 20 m s^{-1} in the same direction as **P**.
P and **Q** collide and remain together after the collision.

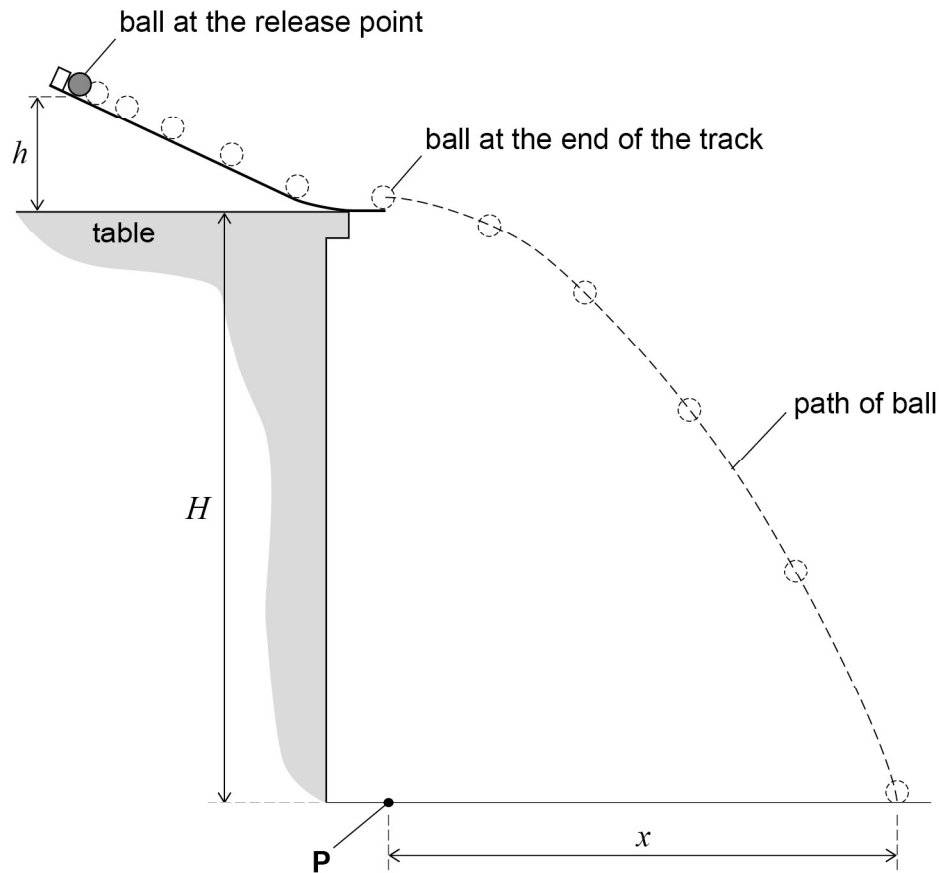What is the total kinetic energy of **P** and **Q** immediately after the collision?

[1 mark]

A 70 kJ   ⬯

B 140 kJ   ⬯

C 980 kJ   ⬯

D 2.0 MJ   ⬯

0 2   **Figure 4** shows an arrangement used to investigate projectile motion of a ball.

Figure 4

The ball is placed on the track at the release point.
The ball is released from rest from a vertical distance h above the table.

When the ball reaches the end of the track, it is a vertical distance H above the horizontal floor.
The ball leaves the track horizontally and lands on the floor at a horizontal distance x from the end of the track.

0 2 . 1   To measure x a student must locate a point **P** on the floor vertically below the end of the track.

Describe a procedure to locate **P**.
You may add detail to **Figure 4** to illustrate your answer.

[1 mark]

_____

_____

_____

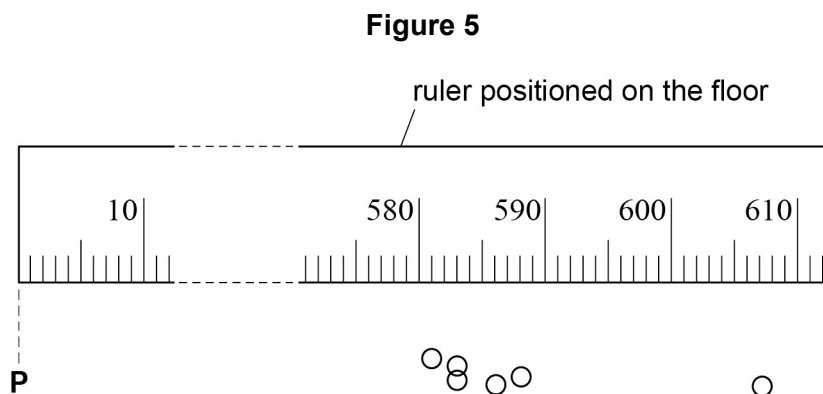_____

Turn over ▶

8

0 2 . 2 A ruler, graduated in mm, is used to determine x.
The student places the ruler on the floor with the zero graduation aligned with **P**.

The student determines x when the ball is released six times at a particular value of h.
He makes marks on the floor where the ball lands.

Figure 5 shows circles that indicate these marks.

Figure 5

ruler positioned on the floor

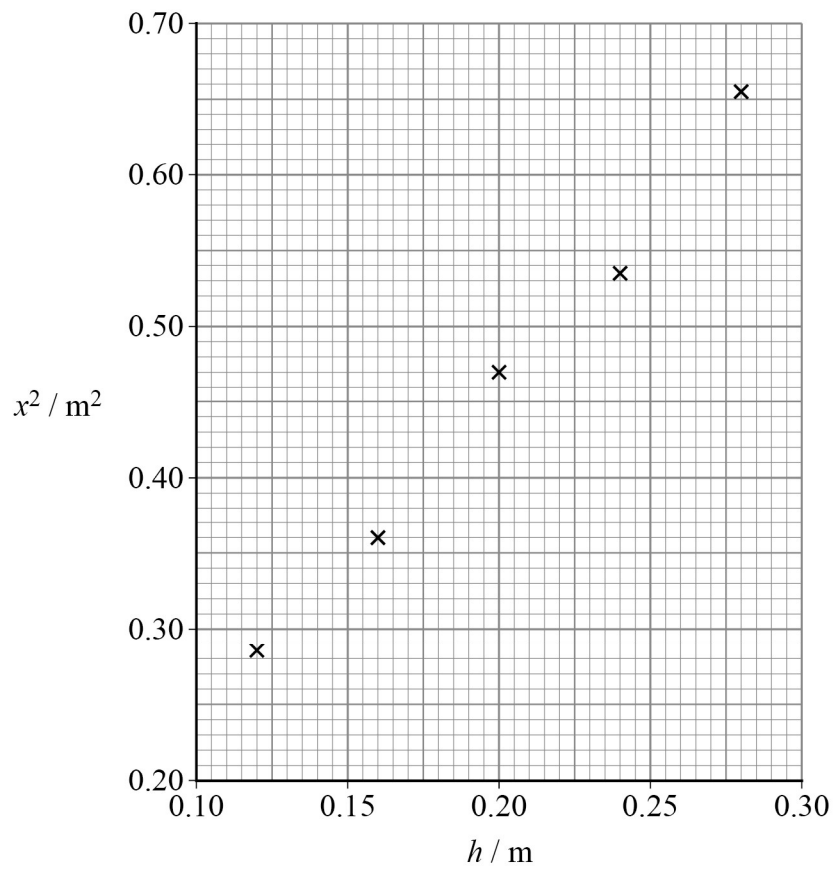Determine x for this value of h.

[3 marks]

$x =$ _____ mm

0 2 . 3 The student obtains values of x corresponding to other values of h.
Figure 6 shows his results.

Figure 6

It can be shown that $\dfrac{x^2}{H} = \dfrac{20}{7}h$
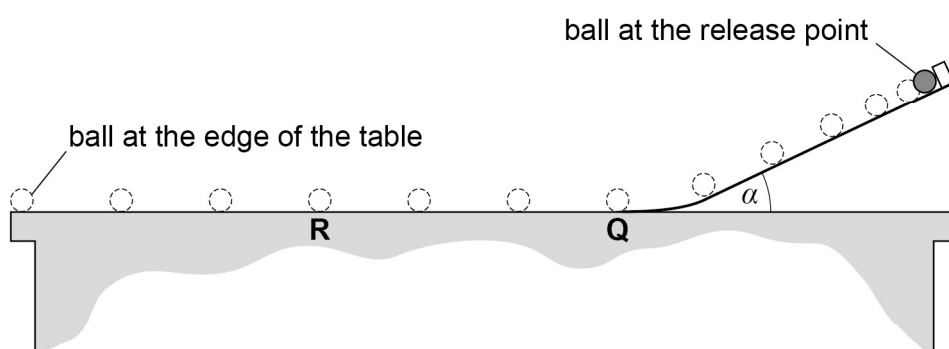
Determine H.

[3 marks]

$H =$ _____ m

Question 2 continues on the next page

Turn over ▶

In a different arrangement, the ball is released from rest and then continues to roll at a constant velocity across a horizontal table, as shown in **Figure 7**.

Figure 7

The bottom of the track is fixed to the table at point **Q**.
The angle between the straight part of the track and the table is α.
A marker is placed at **R**, a point midway between **Q** and the edge of the table.

The student uses a stopwatch to measure the time t for the ball to roll from **Q** to **R**.
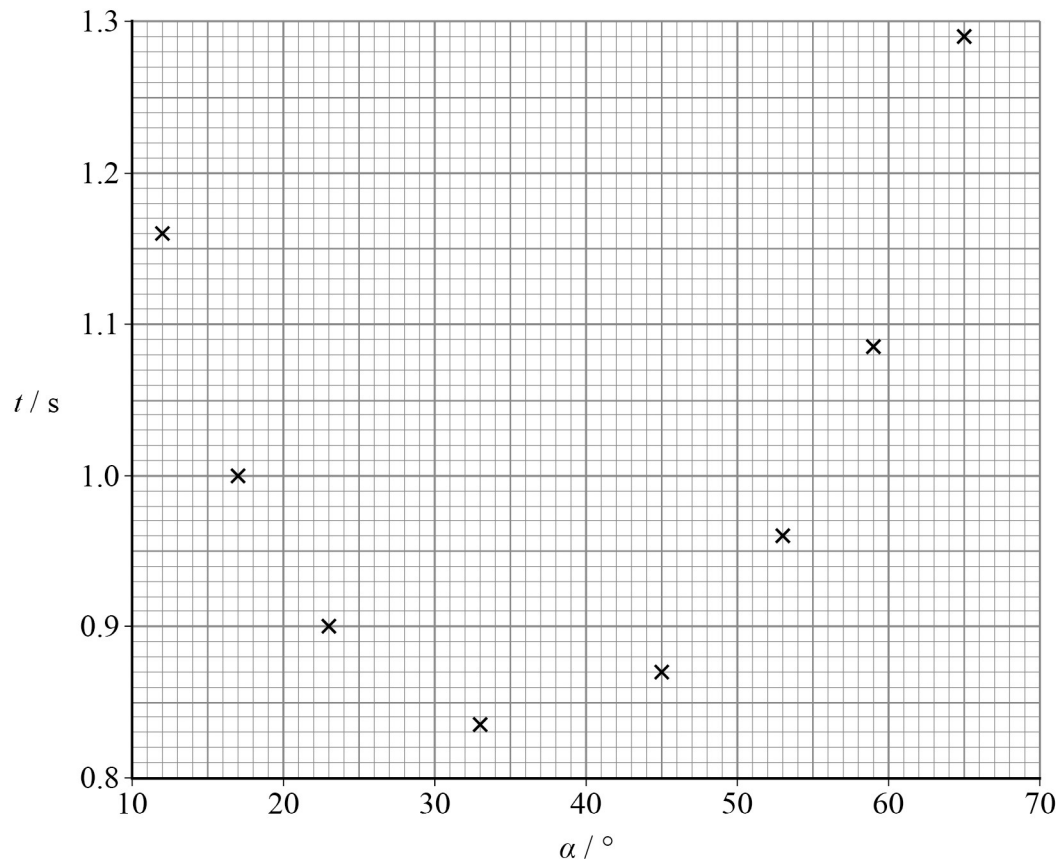
0 2 . 4   Explain why increasing the distance **QR** will reduce the percentage uncertainty in t.
[1 mark]

_____

_____

_____

_____

0 2 . 5 **Figure 8** shows values of t for different values of α.

Figure 8

At a particular value of α the ball rolls from **Q** to **R** at its maximum velocity.

Explain how the student should use **Figure 8** to determine this value of α.
Go on to suggest what further readings should be taken to reduce the uncertainty in this value of α.

[2 marks]

END OF SECTION A
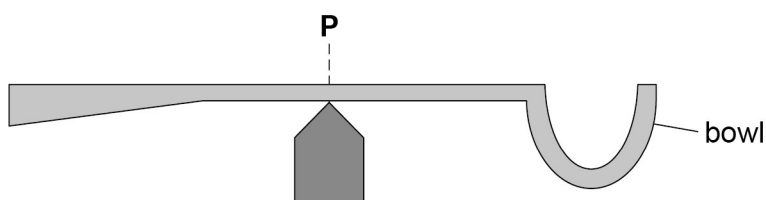
10

Turn over ▶

Section B

Answer **all** questions in this section.

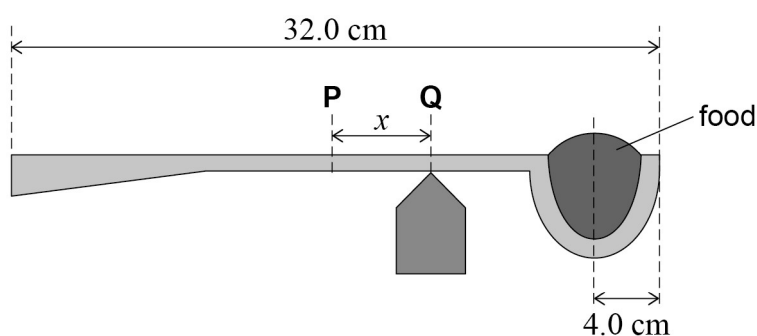**0 3** **Figure 9** shows a spoon used to measure the mass of food.

The empty spoon balances when a pivot is placed under a point **P** halfway along the spoon.

Figure 9

The spoon tilts when food of mass M is placed in the bowl. The spoon is rebalanced by moving the pivot a distance x to the right of **P**. The new position of the pivot is under point **Q** in **Figure 10**.

Figure 10

The total length of the spoon is 32.0 cm. The weight of the food acts through a line at a distance of 4.0 cm from the right-hand edge of the spoon.

0 3 . 1 Explain why the spoon in **Figure 10** is balanced when the pivot is at **Q**.

[2 marks]
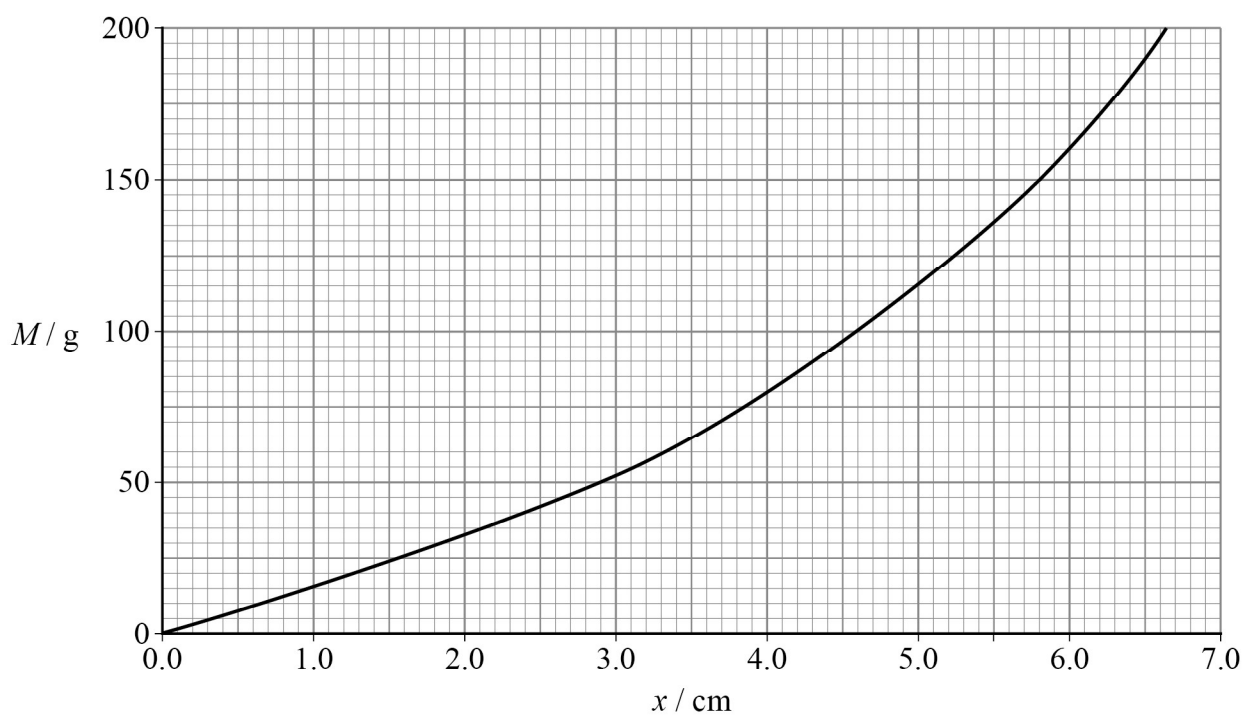
0 3 . 2 The empty spoon has mass m.

Show that, for the arrangement in **Figure 10**,

$$\frac{m}{M} = \frac{(12.0 - x)}{x}$$

[2 marks]

0 3 . 3 **Figure 11** shows how x varies with M.

Figure 11

Determine, using **Figure 11**, the weight of the empty spoon.

[3 marks]

weight = _____ N

Turn over ▶

0 3 . 4 A scale, in grams, is marked on the spoon between **P** and the bowl. **Figure 11** is used to calibrate this scale in intervals of $25\ \text{g}$.

M can be measured by balancing the spoon. The value is read from the point of the scale directly above the pivot.

State and explain how the uncertainty in the value read from the scale changes as M increases.

[3 marks]

10

0 8 An object of mass 0.20 kg moves with an initial velocity u. It collides with a stationary object of mass 0.30 kg.

The objects stick together when they collide.
No external forces act on the objects.

What is the final velocity of the two objects after the collision?

[1 mark]

A $0.40u$

B $0.67u$

C $1.5u$

D $2.5u$

0 9 **P** and **Q** represent displacements.

P

Q

What is the resultant displacement when **P** and **Q** are added?

[1 mark]

A

B

C

D
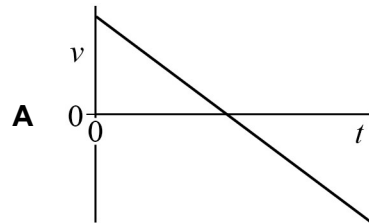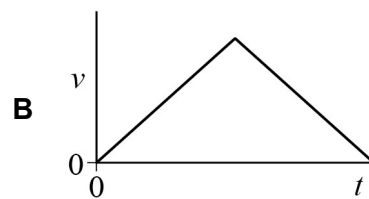
Turn over ▶

Do not write
outside the
box

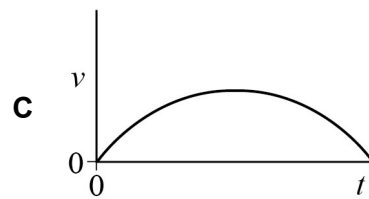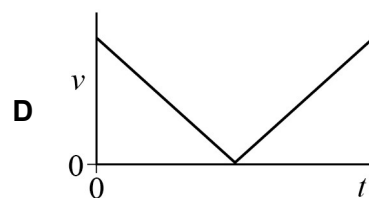**1 0**   A girl kicks a football vertically upwards at time $t = 0$

Air resistance is negligible.

What is the variation of the vertical component of velocity v of the football with t until it reaches the ground?

[1 mark]

A

B

C

D

1 5 Which exchange particle transfers charge during electron capture?

[1 mark]

A meson ⬭

B pion ⬭

C virtual photon ⬭

D W boson ⬭

1 6 A free neutron decays to produce a proton and

[1 mark]

A an electron and an antineutrino. ⬭

B an electron and a neutrino. ⬭

C a positron and an antineutrino. ⬭

D a positron and a neutrino. ⬭

1 7 Two aerials A_1 and A_2 receive radio waves from the same distant transmitter **T**.
The waves have a frequency of $88 \ \text{MHz}$.
The phase difference between the waves received by A_1 and A_2 is 6.6 rad.

What is the distance $A_1T - A_2T$?

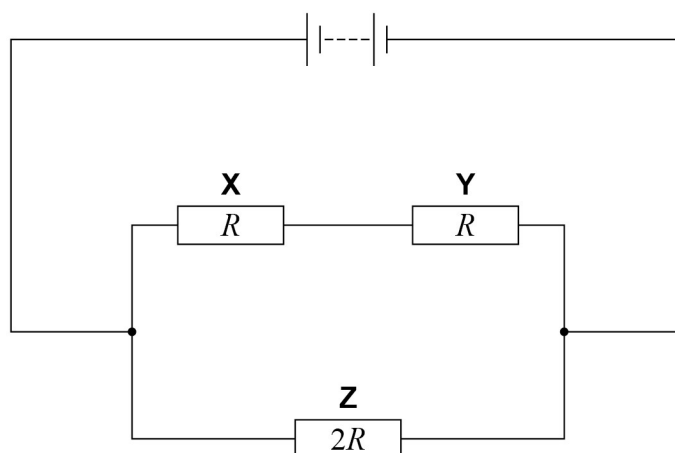[1 mark]

A 1.6 m ⬭

B 3.2 m ⬭

C 3.6 m ⬭

D 7.2 m ⬭

3 2 The diagram shows a circuit containing three resistors **X**, **Y** and **Z**.

X and **Y** each have resistance R.
Z has resistance $2R$.

What is $\dfrac{\text{power in } \mathbf{X}}{\text{power in } \mathbf{Z}}$?

[1 mark]

A $\dfrac{1}{4}$ ⬭

B $\dfrac{1}{2}$ ⬭

C 2 ⬭

D 4 ⬭

3 3 A pellet of mass 25 g travelling horizontally at 40 m s^{-1} enters a fixed wooden block. The pellet stops after travelling a horizontal distance of 2.5 cm in the block.

What is the average resistive force acting on the pellet?

[1 mark]

A 20 N ⬭

B 800 N ⬭

C 1600 N ⬭

D 8000 N ⬭