M1.D

[1]

M2.A

[1]

M3.A

[1]

M4.(a) ANY 2 from

- Slow moving neutrons or low (kinetic) energy neutrons

B1

- (They are in) thermal equilibrium with the moderator / Are in thermal equilibrium with other material (at a temperature of about 300 K)

B1

- Have energies of order of 0.025 eV

- Have (range of) KE similar to that of a gas at 300 K or room temperature

2

(b) (i) Use of $mgh = \frac{1}{2} mv^2$ by substitution or rearranges to make h the subject

PE for use of equation of motion (constant acceleration)

C1

0.086(1) (m) or 0.086(2) (m)

A1

2

(ii) Correct equation for conservation of momentum
$m_1u_1 \ (+\ m_2u_2) = m_1v_1 + m_2v_2$
or states momentum before = momentum after **or**
$p_{before} = p_{after}$

B1

(Correct clear Manipulation =) 0.065 (+ 0) = − 0.0325 + 0.0975
or −0.065 (+ 0) = 0.0325 − 0.0975 must see signs

Condone non−SI here:
65 (+0) = − 32.5 + 97.5

B1

States initial kinetic energy = final kinetic energy **or**
States kinetic energy is conserved

Allow equivalent on RHS where masses are summed in one KE term

B1

(Correct clear Manipulation=) 0.04225 = 0.0105625 + 0.0316875

Or equivalent workings with numbers seen

and 0.04225 = 0.04225 / KE before = KE after

B1

4

(iii) (Percentage / fraction remaining after 1 collision =) ¼ = 25% **seen**

C1

OR
% remaining = 100 × ½ m(1.3^2 − 0.65^2)/ ½ m1.3^2
or hockey ball = 0.0317 **and** initial ke = 0.04225
or their KE_{hb} / 0.04225 or their KE_{hb} / their KE_T

75(%) range 75 to 76

A1

2

(iv) **Demonstrates:**

Slowing down / loss of KE of golf ball is like neutrons slowed down / Neutrons can lose KE by elastic collisions also

B1

Differs:
Collisions in a reactor are not always / rarely head-on
or
KE loss is variable
or
Collisions are not always elastic
or
Ratio of mass of neutron to mass of nucleus is usually much smaller in a reactor

B1

2

(v) Water

B1

1

[13]

M5.(a) m = 16 g = 0.016 kg r = 0.008 m

Use of $V = 4 / 3 \pi r^3$ to give $V = 4 / 3 \pi (0.008)^3$

$= 2.1 \times 10 - 6$ m^3 ✓

The first mark is for calculating the volume

1

Use of density = m / V to give density = $0.016 / 2.1 \times 10^{-6}$ ✓

The second mark is for substituting into the density equation using the correct units

1

Density = 7.4×10^3 kg m^{-3} ✓

The final mark is for the answer.

1

(b) Use of $v^2 = u^2 + 2as$ to give $v^2 = 2 (9.81) (1.27)$ ✓

(allow use of $mg\Delta h = \frac{1}{2} mv^2$)

$v^2 = 25$ (24.9)

The first mark is for using the equation **1**

$v = 5.0$ (m s^{-1}) ✓

The second for the final answer **1**

(c) Use of $v2 = u2 + 2as$ to give $0 = u^2 + 2 (-9.81) (0.85)$ ✓

The first mark is for using the equation **1**

$u^2 = 17$ (16.7)

$u = 4.1$ m s^{-1} ✓

The second for the final answer **1**

(d) Change in momentum = $mv + mu = 0.016 \times 5 + 0.016 \times 4.1$ ✓

The first mark is for using the equation **1**

= 0.15 (0.146) kg m s^{-1} ✓

The second for the final answer **1**

(e) Use of Force = change in momentum / time taken

$= 0.15 / 40 \times 10^{-3}$ ✓

The first mark is for using the equation **1**

= 3.6 N ✓

The second for the final answer

1

(f) Impact time can be increased if the plinth material is not stiff ✓

Alternative

A softer plinth would decrease the change in momentum of the ball (or reduce the height of rebound) ✓

1

Increased impact time would reduce the force of the impact. ✓

Smaller change in momentum would reduce the force of impact ✓

1

[13]

M6.A

[1]

M7.D

[1]

M8.C

[1]

M9.(a) Max GPE of block = Mgh = 0.46 × 9.81 × 0.63 = 2.84 J ✓

The first mark is for working out the GPE of the block

1

Initial KE of block = ½ Mv^2 = 2.84 J

Initial speed of block v^2 = (2 × 2.84) / 0.46

v = 3.51 ms^{-1} ✓

The second mark is for working out the speed of the block initially

1

momentum lost by pellet = momentum gained by block

= Mv = 0.46 × 3.51 = 1.61 kg m s^{-1} ✓

The third mark is for working out the momentum of the block (and therefore pellet)

1

Speed of pellet = 1.58 / m = 1.58 / 8.8 × 10^{-3} = 180 ms^{-1} (183) ✓

The final mark is for the speed of the pellet

1

At each step the mark is for the method rather than the calculated answer

Allow one consequential error in the final answer

(b) As pellet rebounds, change in momentum of pellet greater and therefore the change in momentum of the block is greater ✓

Ignore any discussion of air resistance

1

Initial speed of block is greater ✓

1

(Mass stays the same)

Initial KE of block greater ✓

1

Therefore height reached by steel block is greater than with wooden block ✓

1

(c) Calculation of steel method will need to assume that collision is elastic so that change of momentum can be calculated ✓

1

This is unlikely due to deformation of bullet, production of sound etc. ✓

1

And therefore steel method unlikely to produce accurate results.

[10]