Marks

1. (a) (i) The inertia of a body is its reluctance to change the velocity. 1
A force is required to change the velocity of the body. 1 **2**

(ii) A trolley moves (with uniform velocity) on a friction-compensated runway. No net force is acting on the trolley, however it is moving but is not at rest. (Accept any example that is correct in principle, including motion under terminal velocity or motion on a frictionless surface) 1 **1**

(b) (i) A body (e.g. a satellite revolving round the earth) moving with uniform circular motion. ½
Although the speed is unchanged, the body continuously changes its direction (velocity). ½
The momentum changes. This is brought about by the (centripetal) force. 1 **2**

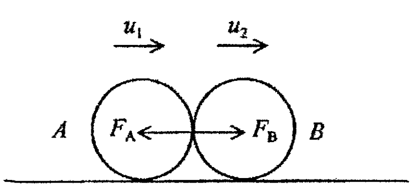
(ii) Set up a friction-compensated runway. ½
To investigate the relation between force and acceleration, a trolley is pulled by one, two ½
and three identical elastic strings which are stretched by the same amount. ½

The corresponding accelerations are recorded and a graph of the force (number of elastic 1
strings) is plotted against the acceleration, which shows a straight line passing through the ½
origin (linear relationship).

To investigate the relation between mass and acceleration, use one elastic string to pull one, ½
two and three trolleys. The corresponding accelerations are recorded and a graph of $\frac{1}{\text{mass}}$ ½
is plotted against the acceleration, which shows a straight line passing through the origin ½
(linear relationship).

Thus, acceleration $\propto \frac{\text{force}}{\text{mass}}$. ½
For a body of mass 1 kg and moves with acceleration 1 m s^{-2}, the force acting on it is 1 N. 1 **6**

(c) Consider the head-on collision between two billiard balls A and B moving with velocities u_1 and u_2 respectively ($u_1 > u_2$) in the same direction. ½



½

Let F_A and F_B be the average forces acting on A and B respectively during collision and Δt be the time during which the two balls are in contact. 1

By Newton's second law, the impulse $F_A\Delta t$ will change the momentum of ball A, i.e. ½

$F_A\Delta t = m_1v_1 - m_1u_1$ ½

Similarly, the momentum of ball B will change by $F_B\Delta t$,

$F_B\Delta t = m_2v_2 - m_2u_2$ ½

By Newton's third law, $F_A = -F_B$ (equal in magnitude but are opposite in direction), therefore ½+½

$m_1v_1 - m_1u_1 = -(m_2v_2 - m_2u_2)$ ½

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ **5**

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1. (a) (i) Momentum of the billiard ball is not conserved. ½
Its momentum perpendicular to the cushion is altered due to the normal reaction. ½ 1

(ii) Momentum of the rocket is not conserved as it is subjected to ½
external forces such as thrust due to ejecting gases, gravity, air resistance. ½ 1

(iii) When an α-particle is emitted, the daughter nucleus recoils in opposite direction and ½
therefore its momentum is not conserved. ½ 1

(b) (i) In a perfectly elastic collision the kinetic energy of the system is conserved. 1

Let the velocity of m_1 after collision be v_1
By the conservation of linear momentum

$m_1u_1 = m_1v_1 + m_2v_2$ or $m_1(u_1 - v_1) = m_2v_2$ – ① ½

As the collision is perfectly elastic,

$\frac{1}{2}m_1u_1^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$ ½

i.e. $m_1(u_1^2 - v_1^2) = m_2v_2^2$ – ② ½

①→② $m_1(u_1^2 - v_1^2) = \frac{m_1^2}{m_2}(u_1 - v_1)^2$ ½

$$m_2(u_1 + v_1) = m_1(u_1 - v_1)$$

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1$$ 3

(ii) (I) $m_1 \gg m_2$, therefore $v_1 \approx u_1$ ½
For example the velocity of a bowling ball is hardly affected by collision with an inflated beach ball of the same size. ½

(II) $m_1 = m_2$, therefore $v_1 = 0$ ½
For example a billiard ball stops when it collides head-on with another stationary billiard ball. ½

(III) $m_1 \ll m_2$, therefore $v_1 \approx -u_1$ ½
For example a ball drops vertically onto the ground (collision with the earth) and rebounds with a reversed velocity and will reach the same height. ½

To slow down the fast neutrons effectively, the stationary targets for collision should be of ½
nearly the same mass of neutrons. Therefore materials with numerous hydrogen centres ½
(such as water) are preferred. 4

(c) (i) Use a spring-loaded gun (i.e. a compressed spring). ½
Use cotton wool or plasticine inside the hole to ensure the collision to be inelastic (i.e. sticky). 1 1½

(ii) The horizontal momentum of the system is conserved, ½
therefore $mv = (m + M)V$ where V is the common velocity just after impact. ½

After the collision, the only forces acting on the system (block + bullet) are the weight and the string tensions (which do no work), therefore the mechanical energy is conserved. 1

From energy conservation, $\frac{1}{2}(m + M)V^2 = (m + M)gh$. ½

As $h = L(1 - \cos\theta)$, by eliminating V, we have ½

$$v = \left(\frac{m+M}{m}\right)\sqrt{2gL(1-\cos\theta)}\ .$$

During the impact the supporting strings may deviate a bit from vertical, ½
therefore some horizontal external force would act on the system ½
resulting in the experimental value lower than the theoretical value. ½
(or L should be measured to the centre of gravity of the block instead of to the top of it) 4½