## COMPLETE ANSWER KEY & STEP-BY-STEP MARKING SCHEME (50 MARKS)

| Q. No. | Step-by-Step Solutions, Equations & Key Marking Points | Marks Allocated |
|---|---|---|
| **Q1** | **(b) 2R, 5πR**<br>Displacement after 2.5 rounds = Straight line distance between diametrically opposite points = $2R$.<br>Total distance = $2.5 \times (2\pi R) = 5\pi R$. | 1 Mark |
| **Q2** | **(c) m**<br>Area under $v$-$t$ graph = $Velocity \times Time = (m/s) \times s = m$ (Displacement). | 1 Mark |
| **Q3** | **(b) Speed**<br>Direction changes continuously, so velocity, acceleration, and momentum change continuously. Only magnitude of velocity (speed) is constant. | 1 Mark |
| **Q4** | **(c) A car maneuvering through congested city traffic**<br>Due to frequent braking and accelerating, speed changes at non-constant rates. | 1 Mark |
| **Q5** | **(c) Mass**<br>Mass is the quantitative measure of the inertia of a body. | 1 Mark |
| **Q6** | **(b) 20 m/s**<br>$a = F / m = 15 / 3 = 5\ m/s^2$.<br>$v = u + at = 0 + (5 \times 4) = 20\ m/s$. | 1 Mark |
| **Q7** | **(b) Act on different bodies in opposite directions**<br>Action and reaction forces never cancel out because they act on mutually distinct bodies. | 1 Mark |
| **Q8** | **(b) Inertia of rest**<br>The carpet moves forward with the stick while dust particles tend to remain at rest due to inertia and separate. | 1 Mark |
| **Q9** | **(a) –1.5 m/s**<br>Conservation of momentum: $m_b v_b + m_r v_r = 0$<br>$(0.020\ kg \times 150\ m/s) + (2\ kg \times v_r) = 0$ &implies; $3 + 2 v_r = 0$ &implies; $v_r = -1.5\ m/s$. | 1 Mark |
| **Q10** | **(a) Accelerated**<br>During the toss, the train speeds up ahead of the coin, which retains the train's lower horizontal speed from the moment of release. | 1 Mark |
| **Q11** | **(a) Both A and R are true and R is the correct explanation of A.** | 1 Mark |
| **Q12** | **(a) Both A and R are true and R is the correct explanation of A.**<br>$F = \Delta p / \Delta t$; increasing $\Delta t$ reduces force on hands. | 1 Mark |
| **Q13** | (i) **Nature:** Speed is a scalar quantity (only magnitude); Velocity is a vector quantity (magnitude and direction). [1 Mark]<br>(ii) **Signs:** Speed is always positive or zero. Velocity can be positive, zero, or negative depending on displacement direction. [1 Mark] | 2 Marks |
| **Q14** | **Statement:** An object continues in its state of rest or of uniform motion in a straight line unless acted upon by an unbalanced external force. [1 Mark]<br>**Reason for name:** Inertia is the inherent natural property of an object to resist changes in its state of motion. Because Newton's first law defines and describes this resistive behavior, it is called the Law of Inertia. [1 Mark] | 2 Marks |
| **Q15** | Given: $u = 0$, $a = 0.2\ m/s^2$, $t = 2\ min = 120\ s$.<br>(a) $v = u + at = 0 + (0.2 \times 120) = 24\ m/s$. [1 Mark]<br>(b) $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 0.2 \times (120)^2 = 0.1 \times 14400 = 1440\ m$ (or $1.44\ km$). [1 Mark] | 2 Marks |
| **Q16** | When the mouth of the inflated balloon is opened, the compressed rubber walls push the trapped air backwards (**Action force**).<br>Simultaneously, the escaping air exerts an equal and opposite force on the balloon pushing it forwards (**Reaction force**). [2 Marks] | 2 Marks |

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| Q17 | **Option A:** $m = 1200\ kg$, $u = 72\ km/h = 72 \times 5/18 = 20\ m/s$, $v = 0$, $t = 10\ s$.<br>$a = (v - u)/t = (0 - 20)/10 = -2\ m/s^2$. [1 Mark]<br>$F = ma = 1200 \times (-2) = -2400\ N$ (Retarding force of $2400\ N$). [1 Mark]<br>**— OR —**<br>**Option B:** Case 1: $F_1 = m_1 a_1 = 2 \times 5 = 10\ N$. [0.5 Mark]<br>Case 2: $F_2 = m_2 a_2 = 4 \times 2 = 8\ N$. [0.5 Mark]<br>Comparison: $10\ N > 8\ N$, therefore accelerating the $2\ kg$ mass at $5\ m/s^2$ requires a greater force. [1 Mark] | 2 Marks |
| Q18 | **Graph:** Plot $v$ vs $t$ showing initial velocity $u$ at $t=0$ and final velocity $v$ at time $t$. [1 Mark]<br>(a) Slope of graph = $a = (v - u)/t$ &implies; $at = v - u$ &implies; $v = u + at$. [1 Mark]<br>(b) Distance $s$ = Area under $v$-$t$ graph = Area of rectangle + Area of triangle<br>$s = (u \times t) + \frac{1}{2} \times t \times (v - u)$. Since $v - u = at$, $s = ut + \frac{1}{2}at^2$. [1 Mark] | 3 Marks |
| Q19 | **Statement:** The rate of change of momentum of an object is directly proportional to the applied unbalanced force and takes place in the direction of the force. [1 Mark]<br>**Derivation:** $p_1 = mu$, $p_2 = mv$ &implies; $\Delta p = m(v - u)$.<br>*Rate of change of momentum* $= m(v - u)/t = ma$.<br>$F \propto ma$ &implies; $F = k \cdot ma$. In SI units, taking $k = 1$, $F = ma$. [1 Mark]<br>**Unit definition:** One Newton ($1\ N$) is the amount of force that produces an acceleration of $1\ m/s^2$ in a body of mass $1\ kg$. [1 Mark] | 3 Marks |
| Q20 | Given: $u = 20\ m/s$, $g = -10\ m/s^2$, at top $v = 0$.<br>(a) $v^2 = u^2 + 2as$ &implies; $0 = (20)^2 + 2(-10)H$ &implies; $20H = 400$ &implies; $H = 20\ m$. [1 Mark]<br>(b) Time to rise: $v = u + at$ &implies; $0 = 20 - 10t$ &implies; $t = 2\ s$.<br>Total time of flight = $2 \times t = 4\ s$. [1 Mark]<br>(c) At highest point: Instantaneous velocity $v = 0\ m/s$; Acceleration $a = 10\ m/s^2$ downwards (due to gravity). [1 Mark] | 3 Marks |
| Q21 | **Option A:** Statement: Total momentum of an isolated system remains conserved in the absence of external unbalanced force. [1 Mark]<br>Let direction of Player A be positive.<br>$m_A = 60\ kg$, $u_A = +5.0\ m/s$; $m_B = 55\ kg$, $u_B = -6.0\ m/s$.<br>Total initial momentum = $(60 \times 5) + (55 \times -6) = 300 - 330 = -30\ kg \cdot m/s$. [1 Mark]<br>After entanglement: $(m_A + m_B)v = (60 + 55)v = 115v$.<br>$115v = -30$ &implies; $v = -30 / 115 \approx -0.26\ m/s$.<br>They will move together at $0.26\ m/s$ in the direction of Player B's original motion. [1 Mark]<br>**— OR —**<br>**Option B:**<br>(i) *Curved turn:* Inertia of direction; passengers' bodies tend to maintain their original straight line path. [1 Mark]<br>(ii) *Seatbelts:* When sudden brakes are applied, upper body continues moving forward due to inertia of motion; seatbelts prevent collision with dashboard. [1 Mark]<br>(iii) *Bubble wrap:* Packing material compresses upon impact, increasing the stopping time ($\Delta t$) and substantially reducing the impulsive force ($F = \Delta p/\Delta t$) on brittle glass. [1 Mark] | 3 Marks |
| Q22 | (a) **v-t graph:** Trapezoid shape: rises from (0,0) to (40, 20 m/s), stays flat until t=140s, drops to 0 at t=160s. [1 Mark]<br>(b) $v_{max} = u + a_1 t_1 = 0 + (0.5 \times 40) = 20\ m/s$.<br>In km/h: $20 \times (18/5) = 72\ km/h$. [1 Mark]<br>(c) Braking time: $v = u - a_2 t_3$ &implies; $0 = 20 - (1.0)t_3$ &implies; $t_3 = 20\ s$. Total time $T = 40 + 100 + 20 = 160\ s$. [1 Mark]<br>(d) Total Distance = Area of Trapezoid = ½ × *(Sum of parallel sides)* × *Height*<br>$s = \frac{1}{2} \times (160 + 100) \times 20 = \frac{1}{2} \times 260 \times 20 = 2600\ m$ (or $2.6\ km$). [1 Mark]<br>(e) *Average Speed = Total Distance / Total Time* $= 2600\ m / 160\ s = 16.25\ m/s$ (or $58.5\ km/h$). [1 Mark] | 5 Marks |
| Q23 | (a) The downward gravitational force (weight $mg$) is exactly cancelled by the upward normal reaction force from the ground. Similarly, any minor horizontal push is opposed by equal static friction. The | 3 Marks |

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| | vector sum of forces is zero ($\Sigma F = 0$, balanced forces), so there is no net acceleration. [1.5 Marks]<br>(b) Momentum is directly proportional to velocity ($p = mv$). At high speeds, momentum is enormous. When a crash occurs, the momentum must drop to zero in a very short span of time ($\Delta t$). From Newton's second law ($F = \Delta p/\Delta t$), this produces an immense impact force causing fatal vehicular deformation and severe injury. [1.5 Marks] | |
| **Q24** | (i) Even though speed is constant, velocity is a vector whose direction changes continuously along the circle; hence it has acceleration. [1 Mark]<br>(ii) Gravitational force of attraction between the Earth and the Moon. [1 Mark]<br>(iii) Radius $r = 42{,}000\ km$, Time $T = 24\ h = 24 \times 3600\ s = 86{,}400\ s$.<br>Distance in 1 orbit = $2\pi r = 2 \times 3.1416 \times 42{,}000 = 263{,}894.4\ km$.<br>$v = 263{,}894.4 / 86{,}400 \approx 3.054\ km/s$ (or $3.05\ km/s$). [2 Marks] | 4 Marks |
| **Q25** | (i) The probe continues moving at constant velocity ($25{,}000\ m/s$) in a straight line. Governed by **Newton's First Law of Motion (Law of Inertia)**. [1 Mark]<br>(ii) On Earth, unseen resistive forces like friction and aerodynamic drag always act against moving objects, requiring continuous engine thrust to counter friction. In space, these opposing forces are completely absent. [1 Mark]<br>(iii) (a) ***Deceleration*** $a = F / m = 4000\ N / 800\ kg = 5\ m/s^2$. [1 Mark]<br>(b) Stopping time: $v = u - at$ &implies; $0 = 25000 - 5t$ &implies; $5t = 25000$ &implies; $t = 5000\ s$ (***1 hour, 23 min, 20 sec***). [1 Mark] | 4 Marks |