CBSE Pattern Test 2 — Laws of Motion

Maximum Marks: 40 · Time Allowed: 90 minutes

General Instructions: All questions are compulsory. The paper has four sections. Section A : Q1–Q10 carry 1 mark each (Q1–Q8 are MCQs chosen from the options; Q9–Q10 are assertion–reason). Section B : Q11–Q15 carry 2 marks each. Section C : Q16–Q20 carry 3 marks each (Q20 is a case study). Section D : Q21 carries 5 marks. In Section A, for each assertion–reason question select the correct alternative: (a) Both A and R are true and R is the correct explanation of A. (b) Both A and R are true but R is NOT the correct explanation of A. (c) A is true but R is false. (d) A is false but R is also false. Take $10\,\text{m/s}^2 = 10\,\text{m/s}^2$ wherever required.

Section	Questions	Marks each	Total marks
A	Q1–Q10	1	10
B	Q11–Q15	2	10
C	Q16–Q20	3	15
D	Q21	5	5

Section A · Q1 – Q10 (1 mark each)

1. A constant force of $10\,\text{N}$ acting on a body of mass $2\,\text{kg}$ produces an acceleration of

(A) $5\,\text{m/s}^2$
(B) $0.2\,\text{m/s}^2$
(C) $20\,\text{m/s}^2$
(D) $12\,\text{m/s}^2$

2. The maximum static friction between a $5\,\text{kg}$ block ($\mu_s = 0.3$) and a horizontal floor is

(A) 15 N
(B) 50 N
(C) 1.5 N
(D) 150 N

3. A ball of mass $0.2\,\text{kg}$ moving at $5\,\text{m/s}$ is struck straight back at $5\,\text{m/s}$. The impulse on the ball is

(A) 2 N s
(B) 0
(C) 1 N s
(D) 10 N s

4. A stone whirled on a string is released suddenly. Immediately it

(A) flies off along the tangent to the circle
(B) flies off towards the centre
(C) falls vertically downwards
(D) flies off radially outward

5. Two masses $8\,\text{kg}$ and $12\,\text{kg}$ connected by a string over a frictionless pulley give an acceleration of

(A) $2\,\text{m/s}^2$
(B) $4\,\text{m/s}^2$
(C) $1\,\text{m/s}^2$
(D) $0.4\,\text{m/s}^2$

6. A $100\ \text{g}$ stone is whirled at $2\ \text{m/s}$ in a horizontal circle of radius $0.5\ \text{m}$. The centripetal force on it is

(A) $0.8\ \text{N}$
(B) $8\ \text{N}$
(C) $0.4\ \text{N}$
(D) $40\ \text{N}$

7. The angle of friction and the angle of repose are equal because both are equal to

(A) $\tan^{-1}\mu$
(B) $\sin^{-1}\mu$
(C) $\cos^{-1}\mu$
(D) μ

8. A man of mass $60\ \text{kg}$ stands in a lift accelerating upward at $2\ \text{m/s}^2$. The weighing machine reads

(A) $72\ \text{kg}$
(B) $60\ \text{kg}$
(C) $48\ \text{kg}$
(D) $66\ \text{kg}$

9. Assertion (A): A rocket can accelerate in empty space. *[1]*
Reason (R): Rocket propulsion is based on the conservation of linear momentum of the rocket and the ejected gases.

10. Assertion (A): Passengers in a bus taking a sharp turn tend to fall outwards. *[1]*
Reason (R): In the frame of the bus a pseudo centrifugal force acts on the passengers in the outward direction.

Section B · Q11 – Q15 (2 marks each)

11. A ball of mass $100\ \text{g}$ hits a wall normally at $5\ \text{m/s}$ and rebounds elastically. Find the impulse imparted to the ball. *[2]*

12. Define the coefficient of static friction and explain why it is in general larger than the coefficient of kinetic friction. *[2]*

13. A stone of mass $0.25\ \text{kg}$ is whirled in a horizontal circle of radius $1.5\ \text{m}$ at $40\ \text{rev/min}$. Find the tension in the string. *[2]*

14. State Newton's first law of motion. Why is it also called the law of inertia? *[2]*

15. A nucleus at rest disintegrates into two fragments of unequal mass. Show that the fragments move in opposite directions, and state whether their momenta are equal in magnitude. *[2]*

Section C · Q16 – Q20 (3 marks each)

16. A rocket with initial mass m_0 burning fuel at the constant rate $\mu_{\text{rate}} = -dm/dt$ ejects gas with exhaust velocity v_{rel}. Derive the velocity of the rocket at any instant when launched vertically, neglecting air resistance. *[3]*

17. A block is projected up a rough inclined plane of inclination 30° with a speed of $10\ \text{m/s}$. If $\mu = 0.2$ and $10\ \text{m/s}^2 = 10\ \text{m/s}^2$, find the distance travelled before it comes momentarily to rest, and state whether it will slide back down. Give a reason. *[3]*

18. A conical-pendulum bob of mass $0.5\ \text{kg}$ moves in a horizontal circle, the string making 30° with the vertical. Find the tension in the string and show that the speed is $v = \sqrt{rg\tan\theta}$. (Evaluate for $r = 0.4\ \text{m}$, $10\ \text{m/s}^2$.) *[3]*

19. A body of mass $0.40\ \text{kg}$ moving north at $10\ \text{m/s}$ is acted on by a constant $8.0\ \text{N}$ force directed south for $30\ \text{s}$. Predict the position of the body at $t = 25\ \text{s}$ and at $t = 100\ \text{s}$. *[3]*

20. Case study: A horizontal turn of radius $250\ \text{m}$ on a hilly road is banked with $\tan\theta = 0.4$. *[3]*

(i) Why are curved roads banked?

(ii) Find the optimum safe speed at which a vehicle can negotiate the turn without depending on friction. (Take $10\ \text{m/s}^2$.)

(iii) If friction is also available with $\mu = 0.2$, find the new maximum safe speed.

Section D · Q21 (5 marks)

21. What is banking of roads? Derive the expression for the maximum safe speed of a vehicle rounding a banked curve when friction is taken into account. *[5]*

Answer Key — ${id}

Section A: 1–5 m/s^2, 2–15 N, 3–2 N s, 4–along the tangent, 5–2 m/s^2, 6–0.8 N, 7–$\tan^{-1}\mu$, 8–72 kg. 9–(a), 10–(a)

11. $J = 0.1 \times (5 - (-5)) = 1\,\text{N s}$.

13. $\omega = 4\pi/3\,\text{rad/s}$; $T = 0.25 \times (4\pi/3)^2 \times 1.5 \approx 6.6\,\text{N}$.

15. Fragments have equal and opposite momenta; the lighter fragment moves faster since momenta are equal in magnitude.

17. $s = 7.43\,\text{m}$; since $\mu = 0.2 < \tan 30^\circ = 0.577$, it slides back down.

18. $T = mg/\cos 30^\circ = 5.77\,\text{N}$; $v = \sqrt{0.4 \times 10 \times 0.577} = 1.52\,\text{m/s}$.

19. $x(25) = -6000\,\text{m}$; $x(100) = -50000\,\text{m}$ (south of origin).

20. (ii) $v = \sqrt{250 \times 10 \times 0.4} = 31.6\,\text{m/s}$. (iii) $v_{\max} = \sqrt{\frac{2500(0.2+0.4)}{1-0.2\times0.4}} = \sqrt{1630} = 40.4\,\text{m/s}$.