



Attempt questions first; check the separate key afterward. Take $g = 10 \text{ m/s}^2$ where needed. Neglect air resistance unless stated.

A. Very short answers - 1 mark each

1. State Newton's first law and explain what inertia means.
2. Define impulse and give its SI unit.
3. Why do action and reaction forces not cancel on one body?
4. Can a body in equilibrium move? Explain briefly.
5. Is static friction always equal to $\mu_s N$? Explain.
6. Which force supplies centripetal acceleration to a car on a level road?
7. Why does a passenger lean forward when a bus brakes suddenly?
8. What does the area under a force-time graph represent?

B. Short answers / practice - 2 marks each

9. A 4 kg body changes velocity from 2 to 10 m/s in 4 s. Find its acceleration and net force.
10. A 0.2 kg ball moving at 15 m/s rebounds at 10 m/s along the same line. Find its impulse, with the initial direction positive.
11. A 2 kg block rests on a horizontal table. A 5 N horizontal force is applied; $\mu_s = 0.4$. Find friction and acceleration.
12. A 5 kg block slides on a horizontal floor with $\mu_k = 0.2$. Find friction and the force needed for constant velocity.
13. A train slows from 30 to 18 m/s in 4 s. Find the least coefficient of static friction preventing luggage from slipping.
14. A 60 kg passenger stands in a lift accelerating upwards at 2 m/s^2 . Find the normal reaction; repeat for downward acceleration.
15. A 0.01 kg bullet leaves a stationary 5 kg gun at 500 m/s relative to the ground. Find the gun's recoil velocity.

16. A 2 kg body moves at 4 m/s in a circle of radius 2 m. Find centripetal force and explain why speed can remain constant.

C. Application / reasoning - 3 marks each

17. Draw a free-body diagram for a block sliding down a rough incline. Write the equations perpendicular and parallel to the plane.
18. A 10 kg block slides down a 30° incline with $\mu_k = 0.2$. Find its acceleration. Use $\sqrt{3} = 1.73$.

19. Two blocks of 2 and 3 kg touch on a smooth floor. A 20 N horizontal force pushes the 2 kg block. Find acceleration and contact force.

20. A 2 kg block on a smooth table is connected over an ideal pulley to a hanging 3 kg mass. Find acceleration and string tension.

21. A 1000 kg car rounds a level curve of radius 50 m. With $\mu_s = 0.5$, find its maximum safe speed and explain why mass cancels.

22. A force rises uniformly from zero to 20 N in 2 s, then falls uniformly to zero in 2 s. Find impulse and velocity change of a 4 kg body.

23. A 1 kg ball moving east at 6 m/s is brought to rest in 0.03 s. Find average force and explain why cushioning reduces impact force.

24. Two perpendicular forces of 9 N and 12 N act at a point. Find the magnitude of the force needed for equilibrium and its angle with the 9 N force.

25. A block takes twice as long to slide a fixed distance from rest down a rough 45° incline as down a smooth one. Find μ_k .

D. Extended practice - 5 marks each

26. Derive $F = ma$ from the momentum form of Newton's second law for constant mass. Use the third law to prove conservation of momentum for an isolated pair.

27. Derive acceleration and tension for two masses m_1 and m_2 hanging over a light, smooth pulley. Evaluate for masses 3 kg and 5 kg.

28. Derive the banking angle of a frictionless road for design speed v and radius r . Find it for $v = 10 \text{ m/s}$ and $r = 20 \text{ m}$. Draw the force diagram.

29. Derive the maximum safe speed on a level circular road. A car has $\mu_s = 0.4$ on a 100 m radius bend; find the limit and discuss wet-road effects.

30. A 5 kg block is pulled by 30 N at 37° above a horizontal floor; $\mu_k = 0.2$. Draw its force diagram, calculate normal reaction, friction and acceleration. Use $\sin 37^\circ = 0.6$.

ANSWER KEY - Numerical / closed questions

- 4) Yes; constant velocity is possible. 5) No; it adjusts up to $\mu_s N$. 9) 2 m/s^2 ; 8 N. 10) -5 N s . 11) 5 N opposite applied force; $a=0$. 12) 10 N; 10 N. 13) 0.30. 14) 720 N; 480 N. 15) -1 m/s . 16) 16 N towards centre. 18) 3.27 m/s^2 . 19) 4 m/s^2 ; 12 N. 20) 6 m/s^2 ; 12 N. 21) $5\sqrt{10} \approx 15.81 \text{ m/s}$. 22) 40 N s; 10 m/s. 23) 200 N west. 24) 15 N; 126.87° to the positive 9 N direction. 25) 0.75. 27) $a=2.5 \text{ m/s}^2$; tension 37.5 N. 28) $\tan\theta=0.5$; $\theta=26.565^\circ$. 29) 20 m/s; lower friction lowers safe speed. 30) $N=32 \text{ N}$; friction 6.4 N; $a=3.52 \text{ m/s}^2$.