PHYSICS

Laws of Motion

Speed TEST 4

Chapter-wise

No. of Questions	Maximum Marks	Time
45	180	1 Hour

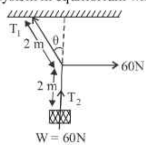
GENERAL INSTRUCTIONS

- This test contains 45 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solutions provided at the end of this book.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

1. A player stops a football weighing 0.5 kg which comes flying towards him with a velocity of 10m/s. If the impact lasts for 1/50th sec. and the ball bounces back with a velocity of 15 m/s, then the average force involved is

(a) 250 N (b) 1250 N (c) 500 N (d) 625 N

2. For the given situation as shown in the figure, the value of θ to keep the system in equilibrium will be



(a) 30° (b) 45° (c) 0° (d) 90°

3. A 5000 kg rocket is set for vertical firing. The exhaust speed is 800 m/s. To give an initial upward acceleration of 20 m/s^2, the amount of gas ejected per second to supply the needed thrust will be (Take g = 10 m/s^2)

(a) 127.5 kg/s (b) 137.5 kg/s
(c) 155.5 kg/s (d) 187.5 kg/s

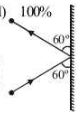
4. Which one of the following statements is correct?

(a) If there were no friction, work need to be done to move a body up an inclined plane is zero.
(b) If there were no friction, moving vehicles could not be stopped even by locking the brakes.
(c) As the angle of inclination is increased, the normal reaction on the body placed on it increases.
(d) A duster weighing 0.5 kg is pressed against a vertical board with force of 11 N. If the coefficient of friction is 0.5, the work done in rubbing it upward through a distance of 10 cm is 0.55 J.

5. A stone is dropped from a height h. It hits the ground with a certain momentum P. If the same stone is dropped from a height 100% more than the previous height, the momentum when it hits the ground will change by :

(a) 68% (b) 41% (c) 200% (d) 100%

6. A 3 kg ball strikes a heavy rigid wall with a speed of 10 m/s at an angle of 60°. It gets reflected with the same speed and angle as shown here. If the ball is in contact with the wall for 0.20s, what is the average force exerted on the ball by the wall?



(a) 150N (b) zero
(c) $150\sqrt{3}$N (d) 300N

RESPONSE GRID	
	1. ⓐⓑⓒⓓ 2. ⓐⓑⓒⓓ 3. ⓐⓑⓒⓓ 4. ⓐⓑⓒⓓ 5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ

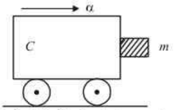
Space for Rough Work

7. The upper half of an inclined plane of inclination θ is perfectly smooth while lower half is rough. A block starting from rest at the top of the plane will again come to rest at the bottom, if the coefficient of friction between the block and lower half of the plane is given by

(a) $\mu = \frac{2}{\tan\theta}$ (b) $\mu = 2\tan\theta$

(c) $\mu = \tan\theta$ (d) $\mu = \frac{1}{\tan\theta}$

8. A block of mass m is in contact with the cart C as shown in the figure.



The coefficient of static friction between the block and the cart is μ. The acceleration α of the cart that will prevent the block from falling satisfies:

(a) $\alpha > \frac{mg}{\mu}$ (b) $\alpha > \frac{g}{\mu m}$ (c) $\alpha \geq \frac{g}{\mu}$ (d) $\alpha < \frac{g}{\mu}$

9. A bridge is in the from of a semi-circle of radius 40m. The greatest speed with which a motor cycle can cross the bridge without leaving the ground at the highest point is ($g = 10\,m\,s^{-2}$) (frictional force is negligibly small)
(a) $40\,m\,s^{-1}$ (b) $20\,m\,s^{-1}$
(c) $30\,m\,s^{-1}$ (d) $15\,m\,s^{-1}$

10. An explosion blows a rock into three parts. Two parts go off at right angles to each other. These two are, 1 kg first part moving with a velocity of $12\,ms^{-1}$ and 2 kg second part moving with a velocity of $8\,ms^{-1}$. If the third part flies off with a velocity of $4\,ms^{-1}$, its mass would be
(a) 5 kg (b) 7 kg (c) 17 kg (d) 3 kg

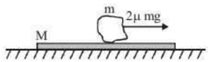
11. A monkey is decending from the branch of a tree with constant acceleration. If the breaking strength is 75% of the weight of the monkey, the minimum acceleration with which monkey can slide down without breaking the branch is

(a) g (b) $\frac{3g}{4}$ (c) $\frac{g}{4}$ (d) $\frac{g}{2}$

12. A car having a mass of 1000 kg is moving at a speed of 30 metres/sec. Brakes are applied to bring the car to rest. If the frictional force between the tyres and the road surface is 5000 newtons, the car will come to rest in
(a) 5 seconds (b) 10 seconds
(c) 12 seconds (d) 6 seconds

13. A spring is compressed between two toy carts of mass m_1 and m_2. When the toy carts are released, the springs exert equal and opposite average forces for the same time on each toy cart. If v_1 and v_2 are the velocities of the toy carts and there is no friction between the toy carts and the ground, then :
(a) $v_1/v_2 = m_1/m_2$ (b) $v_1/v_2 = m_2/m_1$
(c) $v_1/v_2 = -m_2/m_1$ (d) $v_1/v_2 = -m_1/m_2$

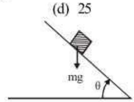
14. A plate of mass M is placed on a horizontal frictionless surface (see figure), and a body of mass m is placed on this plate. The coefficient of dynamic friction between this body and the plate is μ. If a force 2μ mg is applied to the body of mass m along the horizontal, the acceleration of the plate will be



(a) $\frac{\mu m}{M}g$ (b) $\frac{\mu m}{(M+m)}g$ (c) $\frac{2\mu m}{M}g$ (d) $\frac{2\mu m}{(M+m)}g$

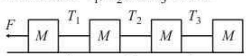
15. The rate of mass of the gas emitted from rear of a rocket is initially 0.1 kg/sec. If the speed of the gas relative to the rocket is 50 m/sec and mass of the rocket is 2 kg, then the acceleration of the rocket in m/sec^2 is
(a) 5 (b) 5.2 (c) 2.5 (d) 25

16. A plank with a box on it at one end is gradually raised about the other end. As the angle of inclination with the horizontal reaches 30° the box starts to slip and slides 4.0 m down the plank in 4.0s. The coefficients of static and kinetic friction between the box and the plank will be, respectively :



(a) 0.6 and 0.5 (b) 0.5 and 0.6
(c) 0.4 and 0.3 (d) 0.6 and 0.6

17. Four blocks of same mass connected by cords are pulled by a force F on a smooth horizontal surface, as shown in fig. The tensions T_1, T_2 and T_3 will be



(a) $T_1 = \frac{1}{4}F,\ T_2 = \frac{3}{2}F,\ T_3 = \frac{1}{4}F$

(b) $T_1 = \frac{1}{4}F,\ T_2 = \frac{1}{2}F,\ T_3 = \frac{1}{2}F$

(c) $T_1 = \frac{3}{4}F,\ T_2 = \frac{1}{2}F,\ T_3 = \frac{1}{4}F$

(d) $T_1 = \frac{3}{4}F,\ T_2 = \frac{1}{2}F,\ T_3 = \frac{1}{2}F$

18. A body of mass M is kept on a rough horizontal surface (friction coefficient μ). A person is trying to pull the body by applying a horizontal force but the body is not moving. The force by the surface on the body is F, then
(a) F = Mg (b) F = μMg
(c) $Mg \leq F \leq Mg\sqrt{1+\mu^2}$ (d) $Mg \geq F \geq Mg\sqrt{1+\mu^2}$

RESPONSE GRID					
	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ
	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ
	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ			

Space for Rough Work

19. Which one of the following motions on a smooth plane surface does not involve force?

(a) Accelerated motion in a straight line
(b) Retarded motion in a straight line
(c) Motion with constant momentum along a straight line
(d) Motion along a straight line with varying velocity

20. A block A of mass m_1 rests on a horizontal table. A light string connected to it passes over a frictionless pulley at the edge of table and from its other end another block B of mass m_2 is suspended. The coefficient of kinetic friction between the block and the table is μ_k. When the block A is sliding on the table, the tension in the string is

(a) $\frac{(m_2 - \mu_k m_1)g}{(m_1 + m_2)}$ (b) $\frac{m_1 m_2(1+\mu_k)g}{(m_1 + m_2)}$

(c) $\frac{m_1 m_2(1-\mu_k)g}{(m_1 + m_2)}$ (d) $\frac{(m_2 + \mu_k m_1)g}{(m_1 + m_2)}$

21. The upper half of an inclined plane with inclination f is perfectly smooth while the lower half is rough. A body starting from rest at the top will again come to rest at the bottom if the coefficient of friction for the lower half is given by

(a) $2\cos\phi$ (b) $2\sin\phi$ (c) $\tan\phi$ (d) $2\tan\phi$

22. A particle describes a horizontal circle in a conical funnel whose inner surface is smooth with speed of 0.5 m/s. What is the height of the plane of circle from vertex of the funnel?

(a) 0.25 cm (b) 2 cm (c) 4 cm (d) 2.5 cm

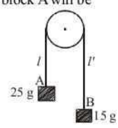
23. You are on a frictionless horizontal plane. How can you get off if no horizontal force is exerted by pushing against the surface?

(a) By jumping
(b) By spitting or sneezing
(c) by rolling your body on the surface
(d) By running on the plane

24. The coefficient of static and dynamic friction between a body and the surface are 0.75 and 0.5 respectively. A force is applied to the body to make it just slide with a constant acceleration which is

(a) $\frac{g}{4}$ (b) $\frac{g}{2}$ (c) $\frac{3g}{2}$ (d) g

25. In the system shown in figure, the pulley is smooth and massless, the string has a total mass 5g, and the two suspended blocks have masses 25 g and 15 g. The system is released from state $\ell = 0$ and is studied upto stage $\ell' = 0$. During the process, the acceleration of block A will be

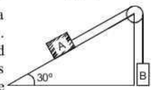


(a) constant at $\frac{g}{9}$
(b) constant at $\frac{g}{4}$
(c) increasing by factor of 3
(d) increasing by factor of 2

26. The minimum force required to start pushing a body up rough (frictional coefficient μ) inclined plane is F_1 while the minimum force needed to prevent it from sliding down is F_2. If the inclined plane makes an angle θ from the horizontal such that $\tan\theta = 2\mu$ then the ratio $\frac{F_1}{F_2}$ is

(a) 1 (b) 2 (c) 3 (d) 4

27. Two blocks are connected over a massless pulley as shown in fig. The mass of block A is 10 kg and the coefficient of kinetic friction is 0.2. Block A slides down the incline at constant speed. The mass of block B in kg is



(a) 3.5 (b) 3.3 (c) 3.0 (d) 2.5

28. Tension in the cable supporting an elevator, is equal to the weight of the elevator. From this, we can conclude that the elevator is going up or down with a

(a) uniform velocity (b) uniform acceleration
(c) variable acceleration (d) either (b) or (c)

29. A particle tied to a string describes a vertical circular motion of radius r continually. If it has a velocity $\sqrt{3\,gr}$ at the highest point, then the ratio of the respective tensions in the string holding it at the highest and lowest points is

(a) 4 : 3 (b) 5 : 4 (c) 1 : 4 (d) 3 : 2

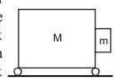
30. It is difficult to move a cycle with brakes on because

(a) rolling friction opposes motion on road
(b) sliding friction opposes motion on road
(c) rolling friction is more than sliding friction
(d) sliding friction is more than rolling friction

31. A plumb line is suspended from a celling of a car moving with horizontal acceleration of a. What will be the angle of inclination with vertical?

(a) $\tan^{-1}(a/g)$ (b) $\tan^{-1}(g/a)$
(c) $\cos^{-1}(a/g)$ (d) $\cos^{-1}(g/a)$

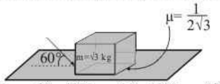
32. A cart of mass M has a block of mass m attached to it as shown in fig. The coefficient of friction between the block and the cart is μ. What is the minimum acceleration of the cart so that the block m does not fall?



(a) μg (b) g/μ
(c) μ/g (d) $M\mu g/m$

RESPONSE GRID					
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ
	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ
	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ	31. ⓐⓑⓒⓓ	32. ⓐⓑⓒⓓ	

33. What is the maximum value of the force F such that the block shown in the arrangement, does not move?



(a) 20 N (b) 10 N (c) 12 N (d) 15 N

34. A block has been placed on an inclined plane with the slope angle θ, block slides down the plane at constant speed. The coefficient of kinetic friction is equal to

(a) $\sin\theta$ (b) $\cos\theta$ (c) g (d) $\tan\theta$

35. A block of mass m is connected to another block of mass M by a spring (massless) of spring constant k. The block are kept on a smooth horizontal plane. Initially the blocks are at rest and the spring is unstretched. Then a constant force F starts acting on the block of mass M to pull it. Find the force of the block of mass m.

(a) $\frac{MF}{(m+M)}$ (b) $\frac{mF}{M}$ (c) $\frac{(M+m)F}{m}$ (d) $\frac{mF}{(m+M)}$

36. A block of mass m is placed on a surface with a vertical cross section given by $y = \frac{x^3}{6}$. If the coefficient of friction is 0.5, the maximum height above the ground at which the block can be placed without slipping is:

(a) $\frac{1}{6}$m (b) $\frac{2}{3}$m (c) $\frac{1}{3}$m (d) $\frac{1}{2}$m

37. A ball of mass 10 g moving perpendicular to the plane of the wall strikes it and rebounds in the same line with the same velocity. If the impulse experienced by the wall is 0.54 Ns, the velocity of the ball is

(a) 27 ms^{-1} (b) 3.7 ms^{-1} (c) 54 ms^{-1} (d) 37 ms^{-1}

38. A block is kept on a inclined plane of inclination θ of length ℓ. The velocity of particle at the bottom of inclined is (the coefficient of friction is μ)

(a) $[2g\ell(\mu\cos\theta - \sin\theta)]^{1/2}$ (b) $\sqrt{2g\ell(\sin\theta - \mu\cos\theta)}$

(c) $\sqrt{2g\ell(\sin\theta + \mu\cos\theta)}$ (d) $\sqrt{2g\ell(\cos\theta + \mu\sin\theta)}$

39. A 100 g iron ball having velocity 10 m/s collides with a wall at an angle 30° and rebounds with the same angle. If the period of contact between the ball and wall is 0.1 second, then the force experienced by the wall is

(a) 10 N (b) 100 N (c) 1.0 N (d) 0.1 N

40. A bullet is fired from a gun. The force on the bullet is given by $F = 600 - 2 \times 10^5\, t$ where, F is in newton and t in second. The force on the bullet becomes zero as soon as it leaves the barrel. What is the average impulse imparted to the bullet?

(a) 1.8 N-s (b) zero (c) 9 N-s (d) 0.9 N-s

41. Two stones of masses m and 2 m are whirled in horizontal circles, the heavier one in radius $\frac{r}{2}$ and the lighter one in radius r. The tangential speed of lighter stone is n times that of the value of heavier stone when they experience same centripetal forces. The value of n is :

(a) 3 (b) 4 (c) 1 (d) 2

42. A 0.1 kg block suspended from a massless string is moved first vertically up with an acceleration of $5ms^{-2}$ and then moved vertically down with an acceleration of $5ms^{-2}$. If T_1 and T_2 are the respective tensions in the two cases, then

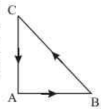
(a) $T_2 > T_1$

(b) $T_1 - T_2 = 1$ N, if $g = 10ms^{-2}$

(c) $T_1 - T_2 = 1$kg f

(d) $T_1 - T_2 = 9.8$ N, if $g = 9.8\, ms^{-2}$

43. Three forces start acting simultaneously on a particle moving with velocity, $\vec{v}$. These forces are represented in magnitude and direction by the three sides of a triangle ABC. The particle will now move with velocity



(a) less than $\vec{v}$

(b) greater than $\vec{v}$

(c) |v| in the direction of the largest force BC

(d) $\vec{v}$, remaining unchanged

44. If in a stationary lift, a man is standing with a bucket full of water, having a hole at its bottom. The rate of flow of water through this hole is R_0. If the lift starts to move up and down with same acceleration and then the rates of flow of water are R_u and R_d, then

(a) $R_0 > R_u > R_d$ (b) $R_u > R_0 > R_d$

(c) $R_d > R_0 > R_u$ (d) $R_u > R_d > R_0$

45. A stationary body of mass 3 kg explodes into three equal pieces. Two of the pieces fly off in two mutually perpendicular directions, one with a velocity of $3\hat{i}\ ms^{-1}$ and the other with a velocity of $4\hat{j}\ ms^{-1}$. If the explosion occurs in 10^{-4} s, the average force acting on the third piece in newton is

(a) $(3\hat{i} + 4\hat{j}) \times 10^{-4}$ (b) $(3\hat{i} - 4\hat{j}) \times 10^{-4}$

(c) $(3\hat{i} - 4\hat{j}) \times 10^{4}$ (d) $-(3\hat{i} + 4\hat{j}) \times 10^{4}$

RESPONSE GRID	33. ⓐⓑⓒⓓ	34. ⓐⓑⓒⓓ	35. ⓐⓑⓒⓓ	36. ⓐⓑⓒⓓ	
	37. ⓐⓑⓒⓓ	38. ⓐⓑⓒⓓ	39. ⓐⓑⓒⓓ	40. ⓐⓑⓒⓓ	41. ⓐⓑⓒⓓ
	42. ⓐⓑⓒⓓ	43. ⓐⓑⓒⓓ	44. ⓐⓑⓒⓓ	45. ⓐⓑⓒⓓ	

PHYSICS CHAPTERWISE SPEED TEST-4			
Total Questions	45	Total Marks	180
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	45	Qualifying Score	60
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

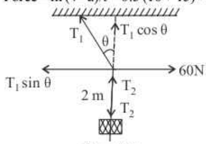
Space for Rough Work

Solution

Speed Test-4

1. **(d)** Here m = 0.5 kg ; u = – 10 m/s;
t = 1/50 s ; v = + 15 ms^{-1}
Force = m (v– u)/t = 0.5 (10 + 15) × 50 = 625 N

2. **(b)**



W = 60N

In eqbm $T_1 \cos\theta = T_2 = 60N$. ...(1)
$T_1 \sin\theta = 60$ N ...(2)
∴ $\tan\theta = 1$
$\theta = 45°$.

3. **(d)** Mass of rocket (m) = 5000 Kg
Exhaust speed (v) = 800 m/s
Acceleration of rocket (a) = 20 m/s^2
Gravitational acceleration (g) = 10 m/s^2
We know that upward force
F = m (g + a) = 5000 (10 +20)
= 5000 × 30 = 150000 N.
We also know that amount of gas ejected

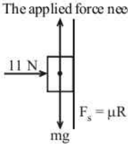
$$\left(\frac{dm}{dt}\right) = \frac{F}{v} = \frac{150000}{800} = 187.5 \text{ kg/s}$$

4. **(b)** (i) If a body is moved up an inclined plane, then the work done against friction will be zero as there is no friction. But work must be done against gravity. So this statement is incorrect.

(ii) This statement is correct, because moving vehicles are stopped by air friction only.

(iii) The normal reaction acting on a body on an inclined plane is given by,
R = mg cosθ
Where θ is the angle of inclination.
As θ increases, cos θ decreases and hence R decreases. So this statement is incorrect.

(iv) The applied force needed to rub the duster upward,



$F_{applied} = mg + \mu R = 0.5 \times 10 + 0.5 \times 11$
$= 5 + 5.5 = 10.5$ N
∴ The work done in rubbing it upward through a distance of 10 cm,
$W = F_{applied} \times d = 10.5 \times 0.10 = 1.05$ J
Hence this statement is incorrect.

5. **(b)** Momentum $P = mv = m\sqrt{2gh}$
($\because v^2 = u^2 + 2gh$; Here $u = 0$)
When stone hits the ground momentum
$P = m\sqrt{2gh}$
when same stone dropped from $2h$ (100% of initial) then momentum
$P' = m\sqrt{2g(2h)} = \sqrt{2}P$
Which is changed by 41% of initial.

6. **(c)** Change in momentum along the wall
$= mv\cos 60° - mv\cos 60° = 0$
Change in momentum perpendicular to the wall
$= mv\sin 60° - (-mv\sin 60°) = 2mv\sin 60°$

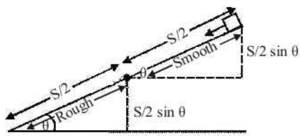
$$\therefore \text{Applied force} = \frac{\text{Change in momentum}}{\text{Time}}$$

$$= \frac{2\,mv\sin 60°}{0.20}$$

$$= \frac{2 \times 3 \times 10 \times \sqrt{3}}{2 \times 20} = 50 \times 3\sqrt{3}$$

$= 150\sqrt{3}$ newton

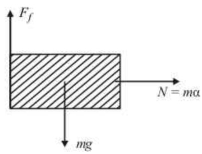
7. **(b)**



For upper half of inclined plane
$v^2 = u^2 + 2a\,S/2 = 2(g\sin\theta)\,S/2 = gS\sin\theta$
For lower half of inclined plane
$0 = u^2 + 2g(\sin\theta - \mu\cos\theta)\,S/2$
$\Rightarrow -gS\sin\theta = gS(\sin\theta - \mu\cos\theta)$
$\Rightarrow 2\sin\theta = \mu\cos\theta$

$$\Rightarrow \mu = \frac{2\sin\theta}{\cos\theta} = 2\tan\theta$$

8. **(c)** Forces acting on the block are as shown in the fig. Normal reaction N is provided by the force mα due to acceleration α



$\therefore \quad N = m\alpha$

For the block not to fall, frictional force, $F_f \geq mg$

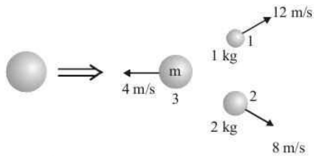
$\Rightarrow \quad \mu N \geq mg$

$\Rightarrow \quad \mu m \alpha \geq mg$

$\Rightarrow \quad \alpha \geq g/\mu$

9. **(b)** $v = \sqrt{gr} = \sqrt{10 \times 40} = 20 \text{ m s}^{-1}$

10. **(a)**



According to conservation of linear momentum

$$P_3 = \sqrt{p_1^2 + p_2^2}$$

$$\Rightarrow m \times 4 = \sqrt{(1 \times 12)^2 + (2 \times 8)^2} = 20 \Rightarrow m = 5 \text{ kg.}$$

11. **(c)** Let T be the tension in the branch of a tree when monkey is descending with acceleration a. Then mg – T = ma; and T = 75% of weight of monkey

$$= \left(\frac{75}{100}\right) mg = \left(\frac{1}{4}\right) mg \text{ or } a = \frac{g}{4}.$$

12. **(d)** $v = u - at \Rightarrow t = \frac{u}{a}$ [As v = 0]

$$t = \frac{u \times m}{F} = \frac{30 \times 1000}{5000} = 6 \text{sec}$$

13. **(c)** Applying law of conservation of linear momentum

$$m_1 v_1 + m_2 v_2 = 0, \ \frac{m_1}{m_2} = -\frac{v_2}{v_1} \text{ or } \frac{v_1}{v_2} = -\frac{m_2}{m_1}$$

14. **(a)** The frictional force acting on M is μmg

$$\therefore \text{Acceleration} = \frac{\mu mg}{M}$$

15. **(c)** $\frac{dM}{dt} = 0.1 \text{ kg/s}, \ v_{gas} = 50 \text{ m/s}$,

Mass of the rocket = 2 kg. Mv = constant

$$-v\frac{dM}{dt} + M\frac{dv}{dt} = 0. \ \therefore \ \frac{dv}{dt} = \frac{1}{M} v \frac{dM}{dt}$$

$$\Rightarrow \text{Acceleration} = \frac{1}{2} \times 50 \times 0.1 = 2.5 \text{ m/s}^2$$

16. **(a)** Coefficient of static friction,

$$\mu_s = \tan 30° = \frac{1}{\sqrt{3}} = 0.577 \cong 0.6$$

$$S = ut + \frac{1}{2}at^2$$

$$4 = \frac{1}{2}a(4)^2 \Rightarrow a = \frac{1}{2} = 0.5$$

[$\because$ s = 4m and t = 4s given]

$$a = g\sin\theta - \mu_k(g)\cos\theta$$

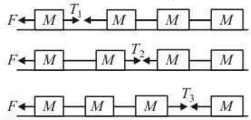
$$\Rightarrow \mu_k = \frac{0.9}{\sqrt{3}} = 0.5$$

17. **(c)** All blocks will move with the same aceleration Let it be a. Then

$$F = 4Ma \Rightarrow a = \frac{F}{4M}$$

From the figures it is clear that

$T_1 = 3\,Ma,\ T_2 = 2\,Ma$ and $T_3 = Ma$



Putting the value of a, we get

$$T_1 = \frac{3}{4}F, \ T_2 = \frac{F}{2} \text{ and } T_3 = \frac{F}{4}$$

18. **(c)** Maximum force by surface when friction works

$$F = \sqrt{f^2 + R^2} = \sqrt{(\mu R)^2 + R^2} = R\sqrt{\mu^2 + 1}$$

Minimum force = R when there is no friction

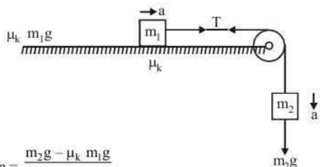
Hence ranging from R to $R\sqrt{\mu^2 + 1}$ [where, R = mg]

19. **(c)** Motion with constant momentum along a straight line. According to Newton's second law rate of change of momentum is directly proportional to force applied.

20. **(b)** For the motion of both the blocks

$m_1 a = T - \mu_k m_1 g$

$m_2 g - T = m_2 a$



$$a = \frac{m_2 g - \mu_k m_1 g}{m_1 + m_2}$$

$$m_2 g - T = (m_2)\left(\frac{m_2 g - \mu_k m_1 g}{m_1 + m_2}\right)$$

solving we get tension in the string

$$T = \frac{m_1 m_2 (1 + \mu_k) g}{m_1 + m_2}$$

21. **(d)** Acceleration of block while sliding down upper half = $g \sin \phi$;

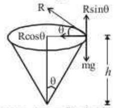
retardation of block while sliding down lower half = – $(g\sin\phi - \mu g\cos\phi)$

For the block to come to rest at the bottom, acceleration in I half = retardation in II half.

$$g\sin\phi = -(g\sin\phi - \mu g\cos\phi)$$

$$\Rightarrow \mu = 2\tan\phi$$

22. **(d)** The particle is moving in circular path



From the figure, $mg = R \sin\theta$ ... (i)

$\frac{mv^2}{r} = R\cos\theta$ ... (ii)

From equations (i) and (ii) we get

$\tan\theta = \frac{rg}{v^2}$ but $\tan\theta = \frac{r}{h}$

$\therefore h = \frac{v^2}{g} = \frac{(0.5)^2}{10} = 0.025\text{m} = 2.5\text{cm}$

23. **(b)** By spitting or sneezing we get a momentum in opposite direction which will help us in getting off the plane. In all other cases we will slip on ice as there is no friction.

24. **(a)** Force required to just move a body

(F) = force due to static friction = $\mu_s mg$

When body moves with a constant acceleration (a) then

$F - f_k = ma$, where f_k is the force of kinetic friction = μ_k mg

$\therefore\ a = \frac{F - f_k}{m} = \frac{F - f_k}{m} = \frac{\mu_s mg - \mu_k mg}{m}$

$= (\mu_s - \mu_k)\, g = (0.75 - 0.5)\, g = \frac{g}{4}$.

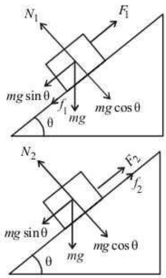
25. **(c)** Considering the two masses and the rope a system, then

Initial net force = $[25 - (15 + 5)]g = 5g$

Final net force = $[(25 + 5) - 15]g = 15\text{ g}$

$\Rightarrow$ (acceleration)$_{\text{final}}$ = 3 (acceleration)$_{\text{initial}}$

26. **(c)**



For the upward motion of the body

$mg \sin\theta + f_1 = F_1$

or, $F_1 = mg\sin\theta + \mu mg\cos\theta$

For the downward motion of the body,

$mg\sin\theta - f_2 = F_2$

or $F_2 = mg\sin\theta - \mu mg\cos\theta$

$\therefore\ \frac{F_1}{F_2} = \frac{\sin\theta + \mu\cos\theta}{\sin\theta - \mu\cos\theta}$

$\Rightarrow\ \frac{\tan\theta + \mu}{\tan\theta - \mu} = \frac{2\mu + \mu}{2\mu - \mu} = \frac{3\mu}{\mu} = 3$

27. **(b)** Considering the equilibrium of B

$-m_B g + T = m_B a$

Since the block A slides down with constant speed.

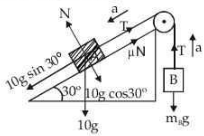
a = 0.

Therefore $T = m_B g$

Considering the equilibrium of A, we get

$10a = 10g\sin 30^\circ - T - \mu N$

where $N = 10g\cos 30^\circ$



$\therefore\ 10a = \frac{10}{2}g - T - \mu \times 10g\cos 30^\circ$

but a = 0, $T = m_B g$

$0 = 5g - m_B g - \frac{0.2\sqrt{3}}{2} \times 10 \times g$

$\Rightarrow m_B = 3.268 \approx 3.3$ kg

28. **(a)** When tension in the cable is equal to the weight of cable, the system is in equilibrium. It means the system is at rest or moving with uniform velocity.

29. **(c)** Tension at the highest point

$T_{top} = \frac{mv^2}{r} - mg = 2mg \quad (\because v_{top} = \sqrt{3gr})$

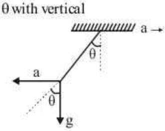
Tension at the lowest point

$T_{bottom} = 2mg + 6mg = 8mg$

$\therefore\ \frac{T_{top}}{T_{bottom}} = \frac{2mg}{8mg} = \frac{1}{4}$.

30. **(d)** When brakes are on, the wheels of the cycle will slide on the road instead of rolling there. It means the sliding friction will come into play instead of rolling friction. The value of sliding friction is more than that of rolling friction.

31. **(a)** When car moves towards right with acceleration a then due to pseudo force the plumb line will tilt in backward direction making an angle θ with vertical

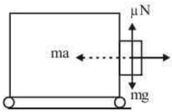


From the figure

$\tan\theta = a/g$

$\therefore \theta = \tan^{-1}(a/g)$

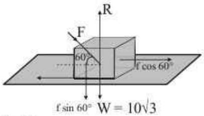
32. **(b)** See fig.



If a = acceleration of the cart, then N = ma

∴ μN = mg or μ ma = mg or a = g/μ

33. **(a)**



f = μR

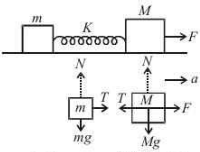
$$F\cos 60° = \mu(W + F\sin 60°)$$

Substituing $\mu = \dfrac{1}{2\sqrt{3}}$ and $W = 10\sqrt{3}$ we get F = 20 N

34. **(d)** When the block slides down the plane with a constant speed, then the inclination of the plane is equal to angle of repose (θ).

Coeff. of friction = tan of the angle of repose = tan θ.

35. **(d)** Writing free body-diagrams for m & M,



we get $T = ma$ and $F - T = Ma$

where T is force due to spring

$\Rightarrow F - ma = Ma$ or, $F = Ma + ma$

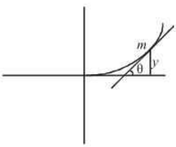
$$\therefore \; a = \frac{F}{M+m}.$$

Now, force acting on the block of mass m is

$$ma = m\left(\frac{F}{M+m}\right) = \frac{mF}{m+M}.$$

36. **(a)** At limiting equilibrium, μ = tan θ

$$\tan\theta = \mu = \frac{dy}{dx} = \frac{x^2}{2} \text{ (from question)}$$



∵ Coefficient of friction μ = 0.5

$$\therefore \quad 0.5 = \frac{x^2}{2}$$

$$\Rightarrow \quad x = \pm 1$$

$$\text{Now, } y = \frac{x^3}{6} = \frac{1}{6} m$$

37. **(a)** As the ball, m = 10 g = 0.01 kg rebounds after striking the wall

∴ Change in momentum = $mv - (-mv) = 2mv$

Inpulse = Change in momentum = $2mv$

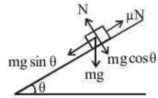
$$\therefore \; v = \frac{\text{Impulse}}{2m} = \frac{0.54 \text{ N s}}{2 \times 0.01 \text{ kg}} = 27 \text{ m s}^{-1}$$

38. **(b)** From the F.B.D.

N = mg cos θ

F = ma = mg sin θ – μN

⇒ a = g(sin θ – μ cos θ)



Now using, $v^2 - u^2 = 2as$

or, $v^2 = 2 \times g(\sin\theta - \mu\cos\theta)\ell$

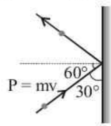
(ℓ = length of incline)

or, $v = \sqrt{2g\ell(\sin\theta - \mu\cos\theta)}$

39. **(a)** During collision of ball with the wall horizontal momentum changes (vertical momentum remains constant)

$$\therefore \quad F = \frac{\text{Change in horizontal momentum}}{\text{Time of contact}}$$

$$= \frac{2P\cos\theta}{0.1} = \frac{2mv\cos\theta}{0.1}$$



$$= \frac{2 \times 0.1 \times 10 \times \cos 60°}{0.1} = 10\text{N}$$

40. **(d)** Given $F = 600 - (2 \times 10^5 t)$

The force is zero at time t, given by

$$0 = 600 - 2 \times 10^5 t$$

$$\Rightarrow \quad t = \frac{600}{2 \times 10^5} = 3 \times 10^{-3} \text{ seconds}$$

$$\therefore \text{Impulse} = \int_0^t F dt = \int_0^{3\times 10^{-3}} (600 - 2 \times 10^5 t)\, dt$$

$$= \left[600t - \frac{2\times10^5 t^2}{2}\right]_0^{3\times10^{-3}}$$

$= 600\times 3\times10^{-3} - 10^5(3\times10^{-3})^2$

$= 1.8 - 0.9 = 0.9Ns$

41. **(d)** According to question, two stones experience same centripetal force

i.e. $F_{C_1} = F_{C_2}$

or, $\frac{mv_1^2}{r} = \frac{2mv_2^2}{(r/2)}$ or, $V_1^2 = 4V_2^2$

So, $V_1 = 2V_2$ i.e., $n = 2$

42. **(b)** $T_1 = m(g+a) = 0.1(10+5) = 1.5N$

$T_2 = m(g-a) = 0.1(10-5) = 0.5N$

$\Rightarrow T_1 - T_2 = (1.5-0.5)N = 1N$

43. **(d)** As shown in the figure, the three forces are represented by the sides of a triangle taken in the same order. Therefore the resultant force is zero. $\vec{F}_{net} = m\vec{a}$.

Therefore acceleration is also zero i.e., velocity remains unchanged.

44. **(b)** Rate of flow of water will depend on the net acceleration due to gravity.

When the lift is moving upward with acceleration a,

$g'_u = g + a$

When the lift is moving downward with acceleration on a, $g'_d = g - a$

$\therefore\ g'_u > g > g'_d \quad \therefore\ R_u > R_0 > R_d$

45. **(d)** According to law of conservation of momentum the third piece has momentum

$= 1\times -(3\hat{i} + 4\hat{j})$ kg ms^{-1}

Impulse = Average force × time

$\Rightarrow$ Average force $= \frac{\text{Impulse}}{\text{time}}$

$= \frac{\text{Change in momentum}}{\text{time}} = \frac{-(3\hat{i}+4\hat{j})\text{kg ms}^{-1}}{10^{-4}\text{s}}$