CLASS – 11

WORKSHEET- LAWS OF MOTION

A. LAWS OF MOTION

(1 Marks Questions)

1. Action and reaction are equal and opposite. Why cannot they cancel each other?

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2. Physical independance of force is a consequence of

(a) first law of motion (b) second law of motion

(c) third law of motion (d) all of these laws.

3. A ball is travelling with uniform translatory motion. This means that

(a) it is at rest.

(b) the path can be a straight line or circular and the ball travels with uniform speed.

(c) all parts of the ball have the same velocity (magnitude and direction) and the velocity is constant.

(d) the centre of the ball moves with constant velocity and the ball spins about its centre uniformly.

(2 Marks Questions)

4. State Newton's second law of motion. Show that it gives a measure of force. Hence define 1N force.

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5. State that Newton's second law of motion is the real law of motion.

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6. State Newton's third law of motion. Derive the law of conservation of linear momentum from it.

(3 Marks Questions)

7. Explain, why

(a) The passengers are thrown forward from their seats, when a speeding bus tops suddenly.

(b) Does a cricketer moves his hand backwards while holding a catch?

(c) Is the boat pushed away when a man jumps out of the boat?

(5 Marks Questions)

8. State and explain the Newton's second law of motion. Hence deduce first and third law of motion from second law of motion. A piece of work is floating on water. What is the net force acting on it?

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B. LINEAR MOMENT AND INERTIA

(1 Marks Questions)

1. Define impulse.

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2. Which one of the following statements is not true?
(a) The same force for the same time causes the same change in momentum for different bodies.

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(b) The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction the force acts.

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(c) A greater opposing force is needed to stop a heavy body than a light body in the same time, if they are moving with the same speed.

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(d) The greater the change in the momentum in a given time, the lesser is the force that needs to be applied.

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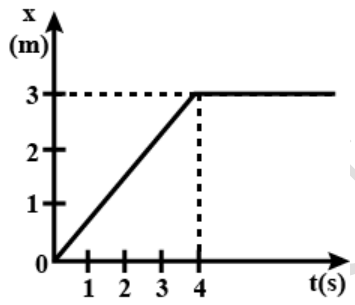
3. A cricket ball of mass 150 g has an initial velocity $\vec{u} = 1\,(3\hat{i} + 4\hat{j})\,m\,s^{-1}$ and a final velocity $\vec{v} = -(3\hat{i} + 4\hat{j})\,m\,s^{-1}$ after being hit. The change in momentum (final momentum-initial momentum) is (in kg m s^1)

(a) zero (b) $-(0.45\hat{i} + 0.6\hat{j})$ (c) $-(0.9\hat{i} + 1.2\hat{j})$ (d) $-5(\hat{i} + \hat{j})$.

4. In the previous problem the magnitude of the momentum transferred during the hit is
(a) Zero (b) 0.75 kg m s^{-1} (c) 1.5 kg m s^{-1} (d) 14 kg m s^{-1}.

5. Conservation of momentum in a collision between particles can be understood from
(a) conservation of energy. (b) Newton's first law only.
(c) Newton's second law only. (d) both Newton's second and third law.

6. The position time graph of a body of mass 2 kg is as given in Figure. What is the impulse on the body at t = 0 s and t = 4 s.



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(2 Marks Questions)

7. A cricketer lowers his hands to catch the ball safely. Explain, why?
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8. Prove impulse-momentum theorem.
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9. A nucleus is at rest in the laboratory frame of reference. Show that if it disintegrates into two smaller nuclei, the products must move in opposite directions.
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10. A shell of mass 0.020 kg is fired by a gun of mass 100 kg. If the muzzle speed of the shell is 80 ms^{-1}.What is the recoil speed of the gun? [Ans. – 0.016 ms^{-1}]

11. A batsman deflects a ball by an angle of 45° without changing its initial speed which is equal to 54 km/h. What is the impulse imparted to the ball? (Mass of the ball is 0.15 kg.)
[Ans. 4.16 kg/ms]

(3 Marks Questions)

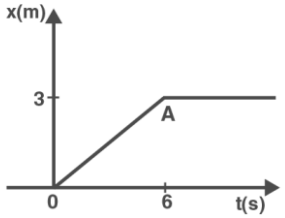
12. A ball moving with am momentum of 5 kg ms^{-1} strikes against a wall at an angle of 45° and is refracted at the same angle. Calculate the change in momentum.
[Ans. – 7.07 kg ms^{-1}]

13. A hammer of mass 1kg moving with a speed of 6 ms^{-1} strikes a wall and comes to rest in 0.1s. Calculate (a) the impulse of force (b) the retardation of the hammer, and (c) the retarding force that stops the hammer.

14. A 100kg gun fires a ball of 1kg horizontally from a cliff of height 500m. It falls on the ground at a distance of 400m from the bottom of the cliff. Find the recoil velocity of the gun. (acceleration due to gravity = 10 ms^{-2}).

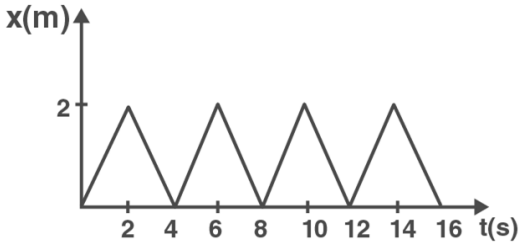
15. Why does a gun recoil on firing? What is recoil velocity? Find the expression for it.

16. Figure shows the position-time graph of a particle of mass 4 kg. What is the (a) force on the particle for $t < 0$, $t > 4$ s, $0 < t < 4$ s? (b) impulse at $t = 0$ and $t = 4$ s? (Consider one-dimensional motion only).



[Ans. 0, 3 kg ms^{-1}, - 3 kg ms^{-1}]

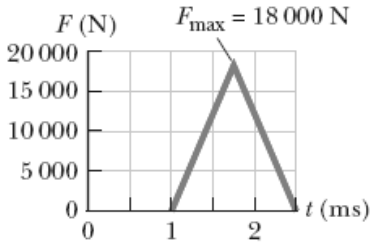
17. Figure shows the position-time graph of a particle of mass 0.04 kg. Suggest a suitable physical context for this motion. What is the time between two consecutive impulses received by the particle? What is the magnitude of each impulse?



[Ans. 8×10^{-4} kg ms^{-1}]

(5 Marks Questions)

18. Figure shows an estimated force time graph for a base ball struck by a bat.



From this curve, determine (i) impulse delivered to the ball (ii) force exerted on the ball (iii) the maximum force on the ball.

[Ans. (i) 1.35×10^4 kg ms^{-1} (ii) 9000N (iii) 18000 N]

C. EQUILIBRIUM OF A BODY

(1 Marks Questions)

1. The magnitude of the net force acting on a car moving with a constant velocity of 30 km/h is

(a) 15N (b) 20N (c) 30N (d) zero

2. The quantity which remains conserved in rocket repulsion

(a) Impulse (b) Force (c) Momentum (d) Acceleration

3. A body subjected to three concurrent forces is found to be in equilibrium. The resultant of any two forces.
(a) is equal to third force (b) is opposite to third force
(c) is collinear with the third force (d) all of these

4. What is the condition for equilibrium of an object?

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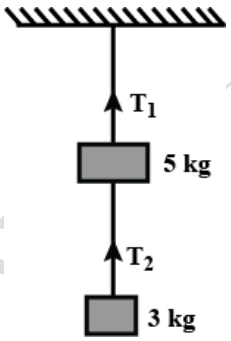
(2 Marks Questions)

5. Two masses of 5 kg and 3 kg are suspended with help of massless inextensible strings as shown in Figure. Calculate T_1 and T_2 when whole system is going upwards with acceleration = 2 m s^2 (use g = 9.8 m s^{-2}).



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(3 Marks Questions)

6. Ten one rupee coins are put on top of one another on a table. Each coin has a mass of m kg. Give the magnitude and direction of
(a) the force on the 7th coin (counted from the bottom) due to all coins above it.
(b) the force on the 7th coin by the eighth coin and
(c) the reaction of the sixth coin on the seventh coin. [Ans. 3mg, 3mg, 6mg]

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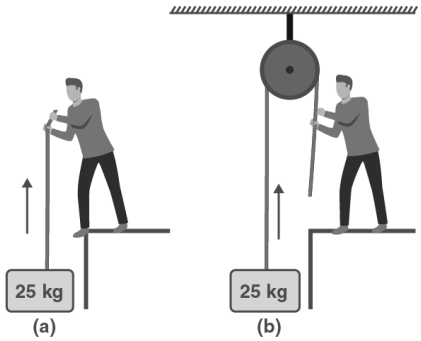
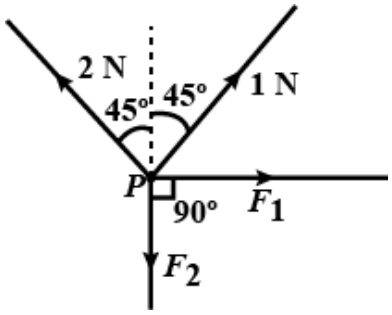
7. A block of mass 25 kg is raised by a 50 kg man in two different ways as shown in Fig. What is the action on the floor by the man in the two cases? If the floor yields to a normal force of 700 N, which mode should the man adopt to lift the block without the floor yielding?



[Ans. 735 N, 245 N]

(5 Marks Questions)

8. There are four forces acting at a point P produced by strings as shown in Figure, which is at rest. Find the forces F_1 and F_2.



D. ACCELERATED MOTION

(1 Marks Questions)

1. A body under the action of a force $\vec{F} = 6\hat{i} - \hat{j}$ N acquires an acceleration of 5 ms^{-2}. The mass of the body is
(a) 2kg (b) 5kg (c) 4kg (d) 6kg

2. Give the magnitude and direction of the net force acting on
(a) a drop of rain falling down with a constant speed

(b) a cork of mass 10 g floating on water

(c) a kite skillfully held stationary in the sky

(d) a car moving with a constant velocity of 30 km/h on a rough road

(e) a high-speed electron in space far from all material objects, and free of electric and magnetic fields.

3. A pebble of mass 0.05 kg is thrown vertically upwards. Give the direction and magnitude of the net force on the pebble,
(a) during its upward motion

(b) during its downward motion

(c) at the highest point where it is momentarily at rest. Do your Solutions change if the pebble was thrown at an angle of 45° with the horizontal direction? Ignore air resistance.

[Ans. (a) 0.5N vertically downwards (b) 0.5N vertically downwards (c) 0.5N vertically downwards]

4. Give the magnitude and direction of the net force acting on a stone of mass 0.1 kg,
(a) just after it is dropped from the window of a stationary train

(b) just after it is dropped from the window of a train running at a constant velocity of 36 km/h

(c) just after it is dropped from the window of a train accelerating with1 m s^{-2}

(d) lying on the floor of a train which is accelerating with 1 m s^{-2}, the stone being at rest relative to the train. Neglect air resistance throughout.

[Ans. (a) 1N vertically downwards (b) 1N vertically downwards (c) 1N vertically downwards (d) 0.1N vertically downwards]

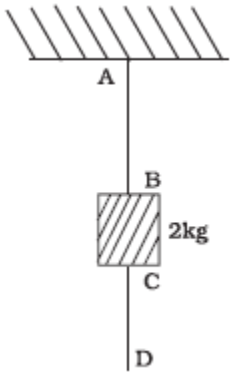
5. A constant retarding force of 50 N is applied to a body of mass 20 kg moving initially with a speed of 15 m s^{-1}. How long does the body take to stop? [Ans. 6s]

6. A person of mass 50 kg stands on a weighing scale on a lift. If the lift is descending with a downward acceleration of 9 m s^{-2}, what would be the reading of the weighing scale? (g = 10 m s^{-2})

(2 Marks Questions)

7. An astronaut accidently gets separated out of his small spaceship accelerating in inter-stellar space at a constant rate of 100 ms^{-2}. What is the acceleration of the astronaut the instant after he is outside the spaceship?

8. A mass of 2kg is suspended with thread AB (Figure). Thread CD of the same type is attached to the other end of 2 kg mass. Lower thread is pulled gradually, harder and harder in the downward direction so as to apply force on AB. Which of the threads will break and why?



9. In the above given problem if the lower thread is pulled with a jerk, what happens?

(3 Marks Questions)

10. A bus starts from rest accelerating uniformly with 4 ms^{-2}. At t = 10s, a stone is dropped out of a window of the bus 2m high. What are the (i) magnitude of velocity and (ii) acceleration of the stone at 10.2s? Take g = 10 ms^{-2}. [Ans. 40.04 m/s, 0]

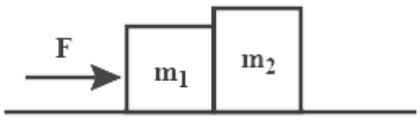
11. A body of mass m moves along X-axis such that its position coordinate at any instant t is $x = at^4 – bt^3 + ct$, where a, b, and c are constants. What is the force acting on the particle at any instant t?

12. A truck starts from rest and rolls down a hill with constant acceleration. It travels a distance of 400m in 20s. Calculate the acceleration and the force acting on it if its mass is 7 metric tons. [Ans. $2ms^{-2}$, 14000N]

13. A 70kg man in sea is being lifted by a helicopter with the help of a rope which can bear a maximum tension of 100 kg wt. With what maximum acceleration the helicopter should rise so that the rope may not break? Take $g = 9.8\ ms^{-2}$. [Ans. $4.2\ ms^{-2}$]

14. Fuel is consumed at the rate of 50 g per second in a rocket. The exhaust gases are rejected at the rate of $5\times10^5\ cms^{-1}$. What is the thrust experienced by the rocket? [Ans. 250N]

15. Two blocks of masses m_1 and m_2 in contact lie on a horizontal smooth surface as shown in fig. The blocks are pushed by a force F. If the two blocks are always in contact, what is the force at their common interface?



16. A constant force acting on a body of mass 3.0 kg changes its speed from 2.0 ms^{-1} to 3.5 ms^{-1} in 25 s. The direction of the motion of the body remains unchanged. What is the magnitude and direction of the force? [Ans. 0.18N]

17. A body of mass 5 kg is acted upon by two perpendicular forces 8 N and 6 N. Give the magnitude and direction of the acceleration of the body. [Ans. 36.87°, with 8N force]

18. The driver of a three-wheeler moving at a speed of 36 km/h sees a child standing in the middle of the road and brings his vehicle to rest in 4.0 s just in time to save the child. What is the average retarding force on the vehicle? The mass of the three-wheeler is 400 kg, and the mass of the driver is 65 kg. [Ans. 1162.5N]

19. A bob of mass 0.1 kg hung from the ceiling of a room by a string 2 m long is set into oscillation. The speed of the bob at its mean position is 1 ms^{-1}. What is the trajectory of the bob if the string is cut when the bob is (a) at one of its extreme positions, (b) at its mean position?

20. Two bodies of masses 10 kg and 20 kg respectively kept on a smooth, horizontal surface are tied to the ends of a tight string. A horizontal force F = 600 N is applied to (i) A, (ii) B along the direction of string. What is the tension in the string in each case?
[Ans. 200N, 400N]

21. Two masses 8 kg and 12 kg are connected at the two ends of a light inextensible string that goes over a frictionless pulley. Find the acceleration of the masses and the tension in the string when the masses are released. [Ans. $2ms^{-2}$, 96N]

22. A stream of water flowing horizontally with a speed of 15 m/s pushes out of a tube of cross-sectional area 10^{-2} m^2 and hits at a vertical wall nearby. What is the force exerted on the wall by the impact of water, assuming that it does not rebound? [Ans. 2250 N]

(5 Marks Questions)

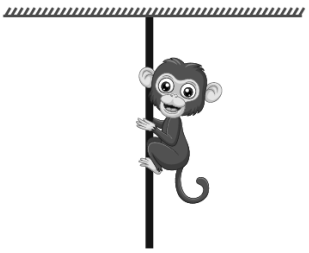
23. (a) A person of mass m is standing in a lift. Find his apparent weight when the lift is (i) moving upward with uniform acceleration a (ii) moving downward with uniform acceleration a(<g) (iii) falls freely
(b) Explain why, it is easier to pull a lawn mover than to push it.

24. A body of mass 0.40 kg moving initially with a constant speed of 10 ms^{-1} to the north is subject to a constant force of 8.0 N directed towards the south for 30 s. Take the instant the force is applied to be t = 0, the position of the body at that time to be x = 0, and predict its position at t = -5 s, 25 s, 100 s. [Ans. -50m, -6km, -50km]

25. A man of mass 70 kg, stands on a weighing machine in a lift, which is moving
(a) upwards with a uniform speed of 10 ms^{-1}.
(b) downwards with a uniform acceleration of 5 ms^{-2}.
(c) upwards with a uniform acceleration of 5 ms^{-2}.
What would be the readings on the scale in each case?
(d) What would be the reading if the lift mechanism failed and it hurtled down freely under gravity?
[Ans. (a) 686N, (b) 34.29 kg wt, (c) 105.7 kg wt (d) weightlessness]

26. A helicopter of mass 1000 kg rises with a vertical acceleration of 15 ms^{-2}. The crew and the passengers weigh 300 kg. Give the magnitude and direction of
(a) force on the floor by the crew and passengers,
(b) the action of the rotor of the helicopter on surrounding air
(c) force on the helicopter due to the surrounding air
[Ans. (a) 7500N, vertically downwards (b) 32500N, vertically downwards (c) 32500N, vertically upwards]

27. A monkey of mass 40 kg climbs on a rope (Fig.) which can stand a maximum tension of 600 N. In which of the following cases will the rope break: the monkey
(a) climbs up with an acceleration of 6 ms^{-2}
(b) climbs down with an acceleration of 4 ms^{-2}
(c) climbs up with a uniform speed of 5 ms^{-1}
(d) falls down the rope nearly freely under gravity? (Ignore the mass of the rope).
[Ans. (a) 640 N, (b) 240 N (c) 400 N (d) 0]



E. FRICTION

(1 Marks Questions)

1. Define angle of friction.

2. A book is lying on the table. What is the angle between the action of the book a on the table and the reaction of the table on the book?
(a) 0° (b) 45° (c) 90° (d) 180°

3. Why are tyres made of rubber not of steel?

4. In a tug of war, the team that pushes harder against the ground wins. Why?

5. A block placed on a rough horizontal surface is pulled by a horizontal force F. Let f be the force applied by the rough surface on the block. Plot a graph of f versus F.

(2 Marks Questions)

6. Sand is thrown on tracks covered with snow. Why?

7. It is difficult to move a cycle along a road with its brakes on. Explain.

8. Why do we slip on a rainy day?

9. A horse has to apply more force to start a cart than to keep it moving. Why?

10. It is difficult to push a box full of clothes than an empty box. Explain.

11. Why us friction called self-adjusting force?

12. Proper inflation of tyres of vehicles saves fuel. Why?

13. How does friction help in walking? Explain.

14. Use component of force, show that it is easier to pull a lawn roller than to push it.

(3 Marks Questions)

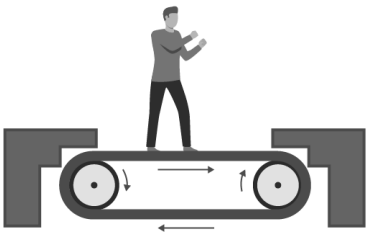
15. A scooter weighs 120 kg f. Brakes are applied so that wheels stop rolling and start skidding. Find the force of friction is the coefficient of friction is 0.4. [Ans. 48 kg f]

16. A suitcase is gently dropped on a conveyor belt moving at 3 m/s. If the coefficient of friction between the belt and the suitcase is 0.5, how far will the suitcase move on the belt before coming to rest? [Ans. 0.92m]

17. A block of mass 2kg rests on a plane inclined at an angle of 30° with the horizontal. The coefficient of friction between the block and the surface is 0.7. What will be the frictional force acting on the block? [Ans. 11.9N]

18. State laws of friction.

19. Figure shows a man standing stationary with respect to a horizontal conveyor belt that is accelerating with 1 ms^{-2}. What is the net force on the man? If the coefficient of static friction, between the man's shoes and the belt is 0.2, up to what acceleration of the belt can the man continue to be stationary relative to the belt? (Mass of the man = 65 kg.)

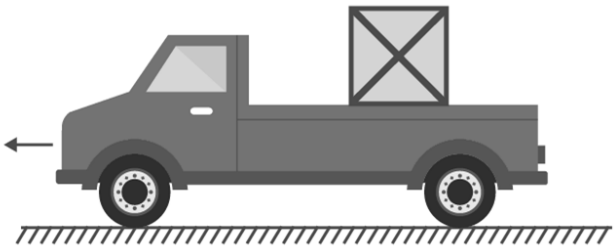


[Ans. 65N, 1.96 ms^{-2}]

20. A block of mass 15 kg is placed on a long trolley. The coefficient of static friction between the block and the trolley is 0.18. The trolley accelerates from rest with 0.5 ms^{-2} for 20 s and then moves with uniform velocity. Discuss the motion of the block as viewed by (a) a stationary observer on the ground, (b) an observer moving with the trolley.

21. The rear side of a truck is open and a box of 40 kg mass is placed 5 m away from the open end as shown in Fig. The coefficient of friction between the box and the surface below it is 0.15. On a straight road, the truck starts from rest and accelerates with 2 ms^{-2}.

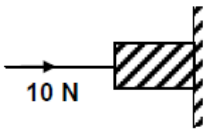
At what distance from the starting point does the box fall off the truck? (Ignore the size of the box). [Ans. 18.57m]



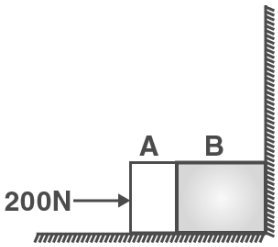
(5 Marks Questions)

22. Define the terms static friction, limiting friction and kinetic friction. Draw the graph between friction and applied force on any object and show static friction, limiting friction and kinetic friction in graph.

23. (a) Draw a graph to show the variation of force of friction with the applied force.
(b) Define angle of repose and deduce the relation with coefficient of static friction.
(c) A horizontal force of 10N is necessary to just hold a block stationary against the wall. Find the weight of the block if coefficient of friction between the block and wall is 0.2.



24. Two bodies A and B of masses 5 kg and 10 kg in contact with each other rest on a table against a rigid wall (Fig.). The coefficient of friction between the bodies and the table is 0.15. A force of 200 N is applied horizontally to A. What are (a) the reaction of the partition (b) the action-reaction forces between A and B? What happens when the wall is removed? Does the Solution to (b) change, when the bodies are in motion? Ignore the difference between μ_s and μ_k. [Ans. 177.95N, 192.65N]



F. CIRCULAR DYNAMICS

(1 Marks Questions)

1. What happens to a stone tied to the end of a string and whirled in a circle if the string suddenly breaks?

2. One end of a string of length l is connected to a particle of mass m and the other to a small peg on a smooth horizontal table. If the particle moves in a circle with speed v the net force on the particle (directed towards the centre) is:
(i) T (ii) $T - mv^2/l$ (iii) $T + mv^2/l$ (iv) 0

3. A stone of mass m tied to the end of a string is revolving in a vertical circle of radius R. The net force at the lowest and highest points of the circle directed vertically downwards are: (choose the correct alternative).

	Lowest Point	Highest Point
(a)	$mg - T_1$	$mg + T_2$
(b)	$mg + T_1$	$mg - T_2$
(c)	$mg + T_1 - (mv_1^2)/R$	$mg - T_2 + (mv_1^2)/R$
(d)	$mg - T_1 - (mv_1^2)/R$	$mg + T_2 + (mv_1^2)/R$

4. Why are mountain roads generally made winding upwards rather than going straight up?

(2 Marks Questions)

5. A cyclist riding at a speed of $14\sqrt{3}$ ms^{-1} takes a turn around a circular road of radius $20\sqrt{3}$m. What is the inclination to the vertical? [Ans. 60°]

6. An aero-plane travelling at a speed of 500 kmh^{-1} tilts at an angle of 30°as it makes a turn. What is the radius of the curve? [Ans. 3.41×10^3 m]

7. Why does a cyclist bend inwards while riding along a curved road?

8. An aircraft executes a horizontal loop at a speed of 720 km/h with its wings banked at 15°. What is the radius of the loop? [Ans. 15.24 km]

(3 Marks Questions)

9. A child revolves a stone of mass 0.5kg tied to the end of the string of length 40cm in a vertical circle. The speed of the stone at the lowest point of the circle is 3 ms^{-1}. Calculate the tension in the string at this point. [Ans. 16.15N]

10. A stone of mass 0.25 kg tied to the end of a string is whirled round in a circle of radius 1.5 m with a speed of 40 rev./min in a horizontal plane. What is the tension in the string? What is the maximum speed with which the stone can be whirled around if the string can withstand a maximum tension of 200 N? [Ans. 6.6N, 34.6 ms^{-1}]

11. If in previous question, the speed of the stone is increased beyond the maximum permissible value, and the string breaks suddenly, which of the following correctly describes the trajectory of the stone after the string breaks:
(a) the stone moves radially outwards,
(b) the stone flies off tangentially from the instant the string breaks,
(c) the stoneflies off at an angle with the tangent whose magnitude depends on the speed of the particle?

12. A train runs along an unbanked circular track of radius of 30 m at a speed of 54 km/h. The mass of the train is 10^6 kg. What provides the centripetal force required for this purpose the engine or the rails? What is the angle of banking required to prevent wearing out of the rail? [Ans. 37.4°]

13. A disc revolves with a speed of 33 1/3 rpm and has a radius of 15 cm. Two coins are placed at 4 cm and 14 cm away from the centre of the record. If the coefficient of friction between the coins and record is 0.15, which of the coins will revolve with the disc? (take $g = 9.8\ ms^{-2}$) [Ans. 12cm]

(5 Marks Questions)

14. What is meant by banking of roads? What is the need for banking of a road? Obtain an expression for the maximum speed with which a vehicle can safely negotiate a curved road banked at an angle θ. The coefficient of friction between the wheels and the road is μ.

15. (a) Why are circular roads banked? Deduce an expression for the angle of banking.
(b) A 1000 kg car rounds a curve on a flat road of radius 50m at a speed of 50 km/h (14m/s). Will the car make the turn or will it skid if the coefficient of friction is 0.60? Justify?

16 Define banking of roads. Also derive an expression for maximum safe velocity of a vehicle on a banked road having coefficient of friction μ. It is easier to roll a barrel than to pull it along the road. Why?

G. CHALLENGING PROBLEMS

1. You may have seen in a circus a motorcyclist driving in vertical loops inside a 'death well' (a hollow spherical chamber with holes, so the spectators can watch from outside). Explain clearly why the motorcyclist does not drop down when he is at the uppermost point, with no support from below. What is the minimum speed required at the uppermost position to perform a vertical loop if the radius of the chamber is 25 m?[Ans. 15.65 ms^{-1}]

2. A 70 kg man stands in contact against the inner wall of a hollow cylindrical drum of radius 3 m rotating about its vertical axis with 200 rev/min. The coefficient of friction between the wall and his clothing is 0.15. What is the minimum rotational speed of the cylinder to enable the man to remain stuck to the wall (without falling) when the floor is suddenly removed? [Ans. 4.7 rad s^{-1}]

3. A thin circular loop of radius R rotates about its vertical diameter with an angular frequency ω. Show that a small bead on the wire loop remains at its lowermost point for $\omega \leq \sqrt{g / R}$. What is the angle made by the radius vector joining the centre to the bead with the vertically downward direction for $\omega = \sqrt{2g/ R}$? Neglect friction. [Ans. 60°]

SPACE FOR ROUGH WORK

SPACE FOR NOTES