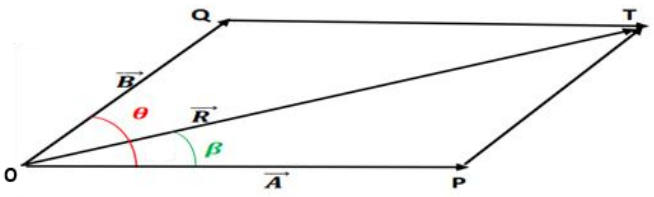
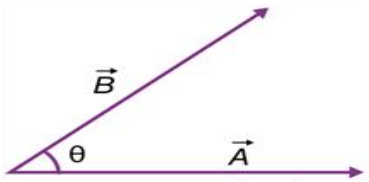
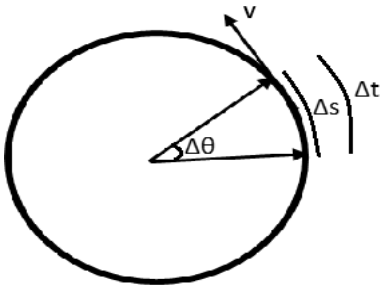
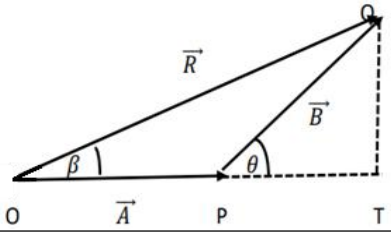
Unit – 2

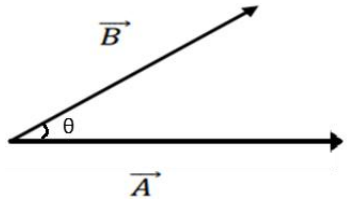
(Force & Motion)

2 MARKSQUESTION

Q. No.	Question	Taxonomy Level	Marking Scheme
Question 1.	**State parallelogram law of vector addition.**	**L1**	
Answer	Statement – "It states that if two vectors acting simultaneously at a point are represented in magnitude & direction by the two sides of a parallelogram drawn from a point, then their resultant is given in magnitude & direction by the diagonal of the parallelogram passing through that point." $\vec{R} = \vec{A} + \vec{B}$  		2
Question 2.	**If $\vec{A}.\vec{B} = \lvert\vec{A} \times \vec{B}\rvert$, then find the value of angle between them.**	**L3**	
Answer	$\vec{A}.\vec{B} = \lvert\vec{A} \times \vec{B}\rvert$ $\Rightarrow AB\ \cos\theta = AB\ \sin\theta$ $\Rightarrow \frac{\sin\theta}{\cos\theta} = 1$ $\Rightarrow \tan\theta = 1$ $\Rightarrow \theta = 45°$		1 1
Question 3.	**If $\vec{A} = 2\hat{i} - 3\hat{k}$ &$\vec{B} = \hat{i} + 2\hat{j} - 4\hat{k}$. Find $\vec{A} \times \vec{B}$?**	**L3**	
Answer	$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$ $= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 0 & -3 \\ 1 & 2 & -4 \end{vmatrix}$ $= \hat{i}(0 - (-6)) - \hat{j}(-8 - (-3)) + \hat{k}(4 - 0)$ $= 6\hat{i} + 5\hat{j} + 4\hat{k}$		1 1
Question 4.	**Define Dot Product of two vectors.**	**L1**	

Answer	Dot product between two vectors is defined as the product of their magnitudes and the cosine of the smaller angle between them. $\vec{A} \cdot \vec{B} = \|A\|\|B\| \cos\theta$  		2
Question 5.	**Why does a cricket player moves his hands in backward direction while catching a ball?**	**L2**	
Answer	$F = \frac{mv - mu}{t}$ A cricket player moves his hand backward while catching a ball, he does so, to provide a greater time for change in momentum. Thus, a small force is exerted by the ball upon the hands and he will feel comfort to catch the ball.		1 1
Question 6.	**Why a cyclist has to bend inward while negotiating a curved track?**	**L2**	
Answer	A cyclist bends inward while negotiating a curve on the road because by leaning towards the center of the curve, a component of the normal reaction from the ground provides the necessary centripetal force to maintain their circular motion around the bend, preventing him from skidding or falling over.		2
Question 7.	**A ball of mass 0.1kg is thrown against a wall. It strikes the wall normally with a velocity of 30m/s & rebounds with a velocity of 20m/s. Calculate the impulse of the force exerted by the ball on the wall.**	**L3**	
Answer	Here, m = 0.1kg, u = 30m/s, v = -20m/s $Impulse\ (I) = change\ in\ momentum$ $= mv - mu$ $= 0.1 \times \{(-20) - 30\}$ $= -5Ns$		1 1
Question 8.	**A body moves in a circular path of radius(r) 2meter with a constant angular acceleration 5 rad/sec^2. Calculate the tangential or linear acceleration of the body.**	**L3**	
Answer	We know that the relation between linear acceleration(a) and angular acceleration(α) is $a = r\alpha$ $\Rightarrow a = 2 \times 5 = 10\ m/sec^2$		1 1
Question 9.	**For what value of m, the vector $\vec{A} = 2\hat{i} + 3\hat{j} - 6\hat{k}$ is perpendicular to $\vec{B} = 3\hat{i} - m\hat{j} + 6\hat{k}$.**	**L3**	
Answer	Here, $\vec{A} = 2\hat{i} + 3\hat{j} - 6\hat{k}\ \vec{B} = 3\hat{i} - m\hat{j} + 6\hat{k}$ $A_x = 2, A_y = 3, A_z = -6 B_x = 3, B_y = -m, B_z = 6$ Two vectors are perpendicular, if the dot product between them is zero i.e., $\vec{A}.\vec{B} = 0$ $\Rightarrow A_xB_x + A_yB_y + A_zB_z = 0$ $\Rightarrow 2.3 + 3.(-m) + (-6).6 = 0$ $\Rightarrow m = (-10)$		1 1

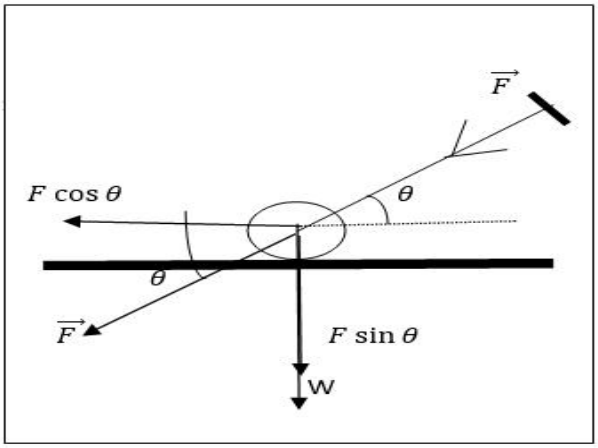
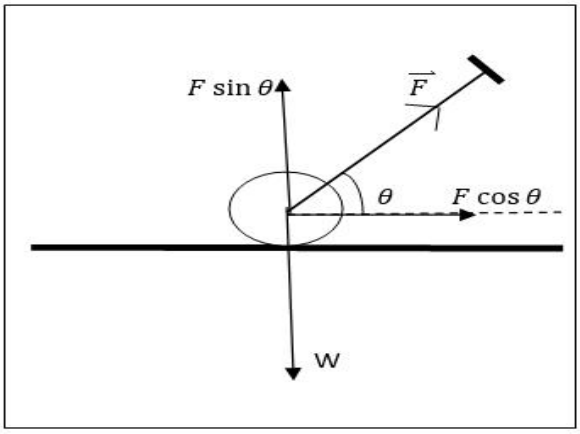
Question 10.	**A body moves in a circular path of radius 3meter with a constant speed v = 9 m/sec. If the mass of body is 2 Kg, then calculate the centripetal force acting on the body.**	**L3**	
Answer	Given r = 3m, v = 9 m/sec and m = 2Kg The centripetal Force $F = \frac{mv^2}{r} = \frac{2\times9^2}{3} = 54\ Newton$		2
Question 11.	**Derive the relation between linear velocity(v), angular velocity(ω) and radius(r).**	**L3**	
Answer	We know that $\Delta\theta = \frac{\Delta s}{r}$ $\Rightarrow \Delta s = r\,\Delta\theta$ $\Rightarrow \left(\frac{\Delta s}{\Delta t}\right) = r\left(\frac{\Delta\theta}{\Delta t}\right)$ $\Rightarrow v = r\,\omega$ Where v = linear velocity and ω = angular velocity whereΔs = small change in linear displacement in time Δt and$\Delta\theta$ = small change in angular displacement 		1 1
Question 12.	**Find the rectangular components of a velocity of 8m/s when one of the components makes an angle 30° with the resultant.**	**L3**	
Answer	Here, $v = 8\ m/s, \quad \theta = 30°$ One component of v = $v\cos\theta = 8\times\cos 30 = 8\times\frac{\sqrt{3}}{2} = 4\sqrt{3}m/s$ Another component of v = $v\sin\theta = 8\times\sin 30 = 8\times\frac{1}{2} = 4m/s$		1 1
Question 13.	**Define centripetal & centrifugal force.**	**L1**	
Answer	<u>Centripetal force -:</u> It is the force required to move a body uniformly in a circle & it acts along the radius & directed towards the center of the circle. <u>Centrifugal Force -:</u> It is the fictitious force (or pseudo force) which acts on the body, rotating with a uniform speed in a circular path along the radius away from the center.		1 1
Question 14.	**State triangle law of vector addition.**	**L1**	
Answer	<u>Statement –:</u> "If two vectors are represented in magnitude & direction by the two sides of a triangle, taken in the same order, then their resultant is represented in magnitude & direction by the third side of the triangle taken in opposite order." 		2

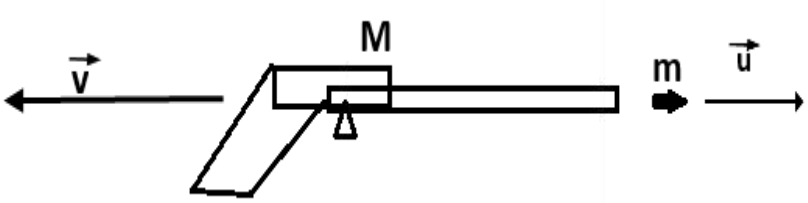
	 $\vec{R} = \vec{A} + \vec{B}$		
Question 15.	**Explain the basic concepts of rocket propulsion.**	**L2**	
Answer	Fuel and oxygen are burnt in the ignition chamber. As hot gases escape from rear opening, with some momentum, rocket moves in forward direction with same momentum, which is the application of conservation of linear momentum.		2
Q16.	**A ball of mass 160 g exerted a force of 5N on the hands of a cricketer and the force acts for 20 seconds. Find the impulse.**	L3	
Ans.	Given , mass m= 160 g = 0.16 kg. Force F = 5N, time t = 20 s Impulse = change in momentum = F × t = 5 × 20 = 100 N.s		2
Q17.	**What will be the maximum and minimum value of the magnitude of the resultant of two vectors $\vec{A}$ and $\vec{B}$?**	L2	
Ans.	Maximum Value = A + B Minimum value = A - B		1 1
Q18.	**What is the relation between time period and frequency of a body moving in a circular path ?**	L1	
Ans.	$\text{Frequency} = \frac{1}{\text{Time period}}$		2

5 MARKSQUESTION

Q. No.	Question	Taxonomy Level	Marking Scheme
Question 1.	**What is necessity of banking the roads. What are the factors upon which angle of banking of road depends? A circular track of radius 600m is to be designed for cars moving at an average speed of 180km/h. What should be the angle of banking of track? (take g = 10m/s^2)**	**L3**	
Answer	Necessity of banking the roads -:		

	As the automobile negotiates a curve, it requires a centripetal force. The frictional force between the ground & the tyres is too small to provide the necessary centripetal force. Therefore, the outer edge of road is raised above its inner edge in order to get the additional force which provides the necessary centripetal force. Angle of banking depends upon:- 1. Velocity of the vehicle. 2. radius of curvature of curve $$\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$$ **Solution:-** Radius of circular track (r) = 600m Average speed of car (v) = 180km/h = 50m/s Acceleration due to gravity (g) = $\boldsymbol{10m/s^2}$ Angle of banking of track $(\theta) = \tan^{-1}\left(\frac{v^2}{rg}\right)$ $$\Longrightarrow \theta = \tan^{-1}\left(\frac{50 \times 50}{600 \times 10}\right) = \tan^{-1}\left(\frac{5}{12}\right) = 22.6°$$		2 1 1 1
Question 2.	**State and prove the principle of conservation of linear momentum.**	**L3**	
Answer	In an isolated system (no external force is applied to the system), total linear momentum of the system remains conserved. From the Newton's 2nd law, we know that, $$\vec{F} = m\vec{a} = \frac{m(\vec{v} - \vec{u})}{t}$$ In an isolated system, $$\vec{F} = 0$$ $$=> \frac{m(\vec{v} - \vec{u})}{t} = 0$$ $=> m(\vec{v} - \vec{u}) = 0$ $=> m\vec{v} - m\vec{u} = 0$ $=> m\vec{v} = m\vec{u}$ $=> final\ momentum\ of\ the\ system$ $= initial\ momentum\ of\ the\ system$		1 1 1 1 1
Question 3.	**Why it is easier to pull a lawn roller than to push?**	**L4**	

Answer	Consider a lawn roller of weight 'W' be pulled or pushed by a force '$\overrightarrow{F}$' making an angle 'θ' with the horizontal direction. The force '$\overrightarrow{F}$' is resolved into two rectangular components: $F\cos\theta = horizontal\ component$ $F\sin\theta = vertical\ component$ **<u>In case of Pushing</u>**:-  The effective horizontal pushing force =$F\cos\theta$,makes the law roller to move forward. The effective weight or normal reaction of the lawn roller = W+$F\sin\theta$ Thus, the apparent weight of the roller increases, so it is difficult to push the lawn roller. **<u>In case of Pulling</u>**:-  The effective horizontal pulling force =$F\cos\theta$,makes the lawn roller to move forward. The effective weight or normal reaction of the lawn roller = W $-$ $F\sin\theta$ Thus, the apparent weight of the roller decreases, so it is easier to pull the lawn roller.		1 1 1 1 1
Question 4.	**Derive the expression for recoil velocity of the gun by the application of conservation of linear momentum.**	**L3**	
Answer	Consider a gun of mass(M) is fired a bullet of mass(m) with a velocity(u) then the gun recoils with a velocity(v) in the backward direction.		1

	 The gun and bullet constitute an isolated system as firing of gun is due to internal force and no external force acting on the system, the momentum of the system remains conserved. **Before firing** Momentum of the bullet = 0 Momentum of the gun = 0 **After firing** Momentum of the bullet = $m\vec{u}$ Momentum of the gun = $M\vec{v}$ Total momentum of the system $= m\vec{u} + M\vec{v}$ Applying conservation of linear momentum, $Momentum\ of\ the\ system\ before\ firing = Momentum\ of\ the\ system\ after\ firing$ $\Rightarrow 0 = m\vec{u} + M\vec{v}$ $\Rightarrow M\vec{v} = -m\vec{u}$ $\Rightarrow \vec{v} = -\frac{m\vec{u}}{M}$ Where $\vec{v}$is recoiling velocity of the gun and negative sign indicates the gun recoils in backward direction.		1 1 1 1
Question 5.	**At what angle two forces $(P+Q)$&$(P-Q)$ should be inclined so as to have a resultant $\sqrt{(3P^2+Q^2)}$.**	**L3**	
Answer	Let the 2 forces are F_1&F_2& F be the resultant of 2 forces. $F_1 = (P+Q)$, $F_2 = (P-Q)$, $F = \sqrt{(3P^2+Q^2)}$ According to parallelogram law of vector addition $F = \sqrt{{F_1}^2 + {F_2}^2 + 2F_1F_2\cos\theta}$ $F^2 = {F_1}^2 + {F_2}^2 + 2F_1F_2\cos\theta$ $\Rightarrow (3P^2+Q^2) = (P+Q)^2 + (P-Q)^2 + 2(P+Q)(P-Q)\cos\theta$ $\Rightarrow 3P^2+Q^2 = P^2+Q^2+2PQ+P^2+Q^2-2PQ+2(P^2-Q^2)\cos\theta$ $\Rightarrow P^2-Q^2 = 2(P^2-Q^2)\cos\theta$ $\Rightarrow \cos\theta = \frac{1}{2}$		1 1 1 1 1

	$\Longrightarrow \theta = 60°$		
Q6.	**The ratio between the magnitude of two forces is 3:5 and the magnitude of their resultant is 35 N. If two forces are inclined at an angle 60^0 then find their individual magnitudes.**	L3	
Ans.	*Given, A:B= 3:5 Let A =* $3x$ *and B=* $5x$ *R= 35 N,* $\theta = 60^0$ *Since,* $R^2 = A^2 + B^2 + 2AB\cos\theta$ $=> (35)^2 = (3x)^2 + (5x)^2 + 2(3x)(5x)\left(\cos 60^0\right)$ $=> (35)^2 = 9x^2 + 25x^2 + 30x^2 \times \frac{1}{2}$ $=> (35)^2 = 49x^2$ $=> 7x = 35$ $=> x = 5$ *So, A=* $3x$ *= 3x 5 =15 N and B=* $5x$ *= 5x 5 = 25 N*		1 1 1 1 1