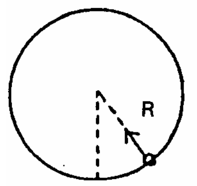
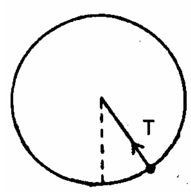
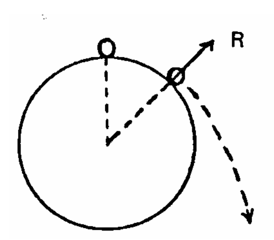
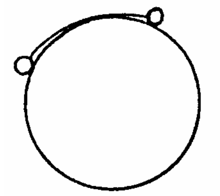
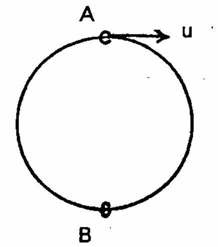
UNIT 8: Circular Motion

Specific Objectives:

1. To study the dynamics of a particle in circular motion.
2. To solve problems involving circular motion.

Detailed Content	Time Ratio	Notes on Teaching
8.1 Circular Motion	4	Teachers may advise students to analyze the kinematics of a particle moving in a circle of radius r. Teachers may start with $\vec{r} = r\hat{e}_r$ and guide students to obtain the acceleration $\ddot{\vec{r}} = -r\dot{\theta}^2\hat{e}_r + r\ddot{\theta}\hat{e}_\theta$ or $\ddot{\vec{r}} = -\frac{v^2}{r}\hat{e}_r + \frac{dv}{dt}\hat{e}_\theta$. Here, students are expected to know that if the particle is moving with constant speed around the circle, then $\ddot{\theta} = 0$ and $\ddot{\vec{r}} = -r\dot{\theta}^2\hat{e}_r = -\frac{v^2}{r}\hat{e}_r$ which is called the centripetal acceleration and is always pointing towards the centre of the circle (as indicated by its negative sign). The corresponding centripetal force (of magnitude $mr\dot{\theta}^2$ or $\frac{mv^2}{r}$) should be provided by some identifiable forces acting on it. For example, the tension of a string, a reaction force or a frictional force. Examples such as a car moving without skidding at a constant speed in a horizontal circle (with or without banking) and conical pendulum should be provided.
8.2 Motion in a Vertical Circle	8	Teachers should remind students that the speed of the particle moving in a vertical circle and hence its angular speed is not constant. Most problems involving vertical circle could be solved by equations of motion or conservation of energy. The following cases should be discussed. 1. A ring or bead threaded in a smooth vertical circular wire. Students are expected to know the condition for the particle to reach the highest point of the circle, the condition for getting zero R and that R can be positive (i.e. pointing toward centre) or negative (i.e. pointing outward centre). 

Detailed Content	Time Ratio	Notes on Teaching
		2. A particle suspended from a fixed point by a light inextensible string. Students are expected to know the condition for the particle to describe a complete circle, the condition for getting zero T and that the subsequent motion after the string gets loose is a projectile under gravity until the string is taut again.  3. A particle moving on the inner rail of a vertical circular wire. This case is similar to case 1 except that the reaction R cannot be negative. 4. A particle moving on the outer surface of a smooth circular cylinder. Again, students should know that the particle will leave the surface (and hence moves as a projectile) when the reaction R is zero.  Teachers are advised to guide students to apply the knowledge and skill obtained in the above cases to solve related problems. The following show three typical examples.

Detailed Content	Time Ratio	Notes on Teaching
	12	*Example 1* Two particles connected by a string move on the outer surface of a smooth cylinder.  *Example 2* Two beads are free to move on a circular smooth wire. Bead A is projected with speed u. The subsequent motion of A and B depends on the coefficient of restitution. Students have to apply the principle of momentum to solve the problem.  *Example 3* A bead threaded to a circular wire is projected with a horizontal velocity u at the lowest point. The coefficient of friction is μ. In this example, students should note that the law of conservation of energy fails to apply and they have to solve the equation of motion as a differential equation.