Circular Motion Problems

Horizontal Circular Motion

1. (I) A child sitting 1.10 m from the center of a merry-go-round moves with a speed of $1.25\,\mathrm{m/s}$. Calculate (*a*) the centripetal acceleration of the child, and (*b*) the net horizontal force exerted on the child $(\text{mass} = 25.0\,\mathrm{kg})$.

   a. 1.42m/s^2 **b. 35.5N**

2. (I) A horizontal force of 210 N is exerted on a 2.0-kg discus as it rotates uniformly in a horizontal circle (at arm's length) of radius 0.90 m. Calculate the speed of the discus.

Speed = 9.72m/s

6. (II) A device for training astronauts and jet fighter pilots is designed to rotate a trainee in a horizontal circle of radius 12.0 m. If the force felt by the trainee on her back is 7.85 times her own weight, how fast is she rotating? Answer in m/s

Speed = 30.4m/s

Vertical Circular Motion

Concepts

1. (II) A bucket of water can be whirled in a vertical circle without the water spilling out, even at the top of the circle when the bucket is upside down. Explain.

The bucket has a centripetal acceleration toward the center of the swing. The water has a downward acceleration due to gravity.

As the bucket swings, its normal force pushes the water toward the center of the swing. At the top of the swing, the bucket is accelerating downward as fast (or faster) than the water is accelerating downward due to gravity. Therefore, the bottom of the bucket always remains in contact with the water.

2. A child on a sled comes flying over the crest of a small hill, as shown in Fig. 5–31. His sled does not leave the ground (he does not achieve "air"), but he feels the normal force between his chest and the sled decrease as he goes over the hill. Explain this decrease using Newton's second law.

2nd Law: Net Force = ma.

When an object is following a curve, the <u>net</u> force on the object equals the centripetal force = mv^2/r. At the top of the hill, the centripetal force required to keep the child following the hilltop curve is equal to the force of gravity (the child's weight). On flat ground, the net force acting on the child is the sum of the upward force and the child's downward weight. At the top of the hill, since the net force acting on the child equals his weight, there can be no normal force. The child does not feel a force between his chest and the sled.

3. Why do bicycle riders lean inward when rounding a curve at high speed?

When bicyclists travel in a circle, there must be a centripetal force pushing them toward the center of the turn. That force is provided by friction, and friction pushes on the lowest part of the bike, where the tires touch the road. If riders remained upright, this sideways force pushing against the bottom of the tires would cause them to flip over in the same way that a football player flips over when someone "takes him out at the knees."