Sample Problem Set I Solutions

Circular Motion and Gravitation

ADDITIONAL PRACTICE B

Givens *Solutions*

1. $m_1 = 235\ \text{kg}$
$m_2 = 72\ \text{kg}$
$r = 25.0\ \text{m}$
$F_c = 1850\ \text{N}$

$$m_{tot} = m_1 + m_2 = 235\ \text{kg} + 72\ \text{kg} = 307\ \text{kg}$$

$$F_c = m_{tot}\, a_c = m_{tot}\, \frac{v_t^2}{r}$$

$$v_t = \sqrt{\frac{rF_c}{m_{tot}}} = \sqrt{\frac{(25.0\ \text{m})(1850\ \text{N})}{307\ \text{kg}}} = \boxed{12.3\ \text{m/s}}$$

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2. $m = 30.0\ \text{g}$
$r = 2.4\ \text{m}$
$F_T = 0.393\ \text{N}$
$g = 9.81\ \text{m/s}^2$

$$F_T = F_g + F_c = mg + m\frac{v_t^2}{r}$$

$$v_t = \sqrt{\frac{r(F_T - mg)}{m}} = \sqrt{\frac{(2.4\ \text{m})[0.393\ \text{N} - (30.0 \times 10^{-3}\ \text{kg})(9.81\ \text{m/s}^2)]}{30.0 \times 10^{-3}\ \text{kg}}}$$

$$v_t = \sqrt{\frac{(2.4\ \text{m})(0.393\ \text{N} - 0.294\ \text{N})}{30.0 \times 10^{-3}\ \text{kg}}} = \frac{(2.4\ \text{m})(0.099\ \text{N})}{30.0 \times 10^{-3}\ \text{kg}}$$

$$v_t = \boxed{2.8\ \text{m/s}}$$

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3. $v_t = 8.1\ \text{m/s}$
$r = 4.23\ \text{m}$
$m_1 = 25\ \text{g}$
$g = 9.81\ \text{m/s}^2$

$$F_g = F_c$$

$$m_1 g = \frac{m_2 v_t^2}{r}$$

$$m_2 = \frac{m_1 g r}{v_t^2}$$

$$m_2 = \frac{(25 \times 10^{-3}\ \text{kg})(9.81\ \text{m/s}^2)(4.23\ \text{m})}{(8.1\ \text{m/s})^2} = \boxed{1.6 \times 10^{-2}\ \text{kg}}$$

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4. $v_t = 75.57\ \text{km/h}$
$m = 92.0\ \text{kg}$
$F_c = 12.8\ \text{N}$

$$F_c = m\frac{v_t^2}{r}$$

$$r = \frac{mv_t^2}{F_c} = \frac{(92.0\ \text{kg})[(75.57\ \text{km/h})(10^3\ \text{m/km})(1\ \text{h}/3600\ \text{s})]^2}{12.8\ \text{N}}$$

$$r = \boxed{3.17 \times 10^3\ \text{m} = 3.17\ \text{km}}$$

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5. $m = 75.0\ \text{kg}$
$r = 446\ \text{m}$
$v_t = 12\ \text{m/s}$
$g = 9.81\ \text{m/s}^2$

$$F_c = \frac{mv_t^2}{r} = \frac{(75.0\ \text{kg})(12\ \text{m/s})^2}{446\ \text{m}} = \boxed{24\ \text{N}}$$

$$F_T = F_c + mg = 24\ \text{N} + (75.0\ \text{kg})(9.81\ \text{m/s}^2)$$

$$F_T = 24\ \text{N} + 736\ \text{N} = \boxed{7.60 \times 10^2\ \text{N}}$$

Name:_____ Class:_____ Date:_____

Circular Motion and Gravitation

Problem B

CENTRIPETAL FORCE

PROBLEM

The royal antelope of western Africa has an average mass of only 3.2 kg. Suppose this antelope runs in a circle with a radius of 30.0 m. If a force of 8.8 N maintains this circular motion, what is the antelope's tangential speed?

SOLUTION

Given: $m = 3.2$ kg
$r = 30.0$ m
$F_c = 8.8$ N

Unknown: $v_t = ?$

Use the equation for centripetal force, and rearrange it to solve for tangential speed.

$$F_c = \frac{mv_t^2}{r}$$

$$v_t = \sqrt{\frac{F_c r}{m}} = \sqrt{\frac{(8.8\text{ N})(30.0\text{ m})}{3.2\text{ kg}}} = \sqrt{82\frac{\text{m}^2}{\text{s}^2}}$$

$$v_t = 9.1\text{ m/s}$$

ADDITIONAL PRACTICE

1. Gregg Reid of Atlanta, Georgia, built a motorcycle that is over 4.5 m long and has a mass of 235 kg. The force that holds Reid and his motorcycle in a circular path with a radius of 25.0 m is 1850 N. What is Reid's tangential speed? Assume Reid's mass is 72 kg.
2. With an average mass of only 30.0 g, the mouse lemur of Madagascar is the smallest primate on Earth. Suppose this lemur swings on a light vine with a length of 2.4 m, so that the tension in the vine at the bottom point of the swing is 0.393 N. What is the lemur's tangential speed at that point?
3. In 1994, Mata Jagdamba of India had very long hair. It was 4.23 m long. Suppose Mata conducted experiments with her hair. First, she determined that one hair strand could support a mass of 25 g. She then attached a smaller mass to the same hair strand and swung it in the horizontal plane. If the strand broke when the tangential speed of the mass reached 8.1 m/s, how large was the mass?
4. Pat Kinch used a racing cycle to travel 75.57 km/h. Suppose Kinch moved at this speed around a circular track. If the combined mass of Kinch and the cycle was 92.0 kg and the average centripetal force was 12.8 N, what was the radius of the track?

5. In 1992, a team of 12 athletes from Great Britain and Canada rappelled 446 m down the CN Tower in Toronto, Canada. Suppose an athlete with a mass of 75.0 kg, having reached the ground, took a joyful swing on the 446 m-long rope. If the speed of the athlete at the bottom point of the swing was 12 m/s, what was the centripetal force? What was the tension in the rope? Neglect the rope's mass.