Mathematics of Circular Motion

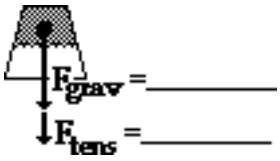
Read from **Lesson 2** of the **Circular and Satellite Motion** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/circles/u6l2a.html
http://www.physicsclassroom.com/Class/circles/u6l2b.html
http://www.physicsclassroom.com/Class/circles/u6l2c.html

MOP Connection: Circular Motion and Gravitation: sublevel 5

1. The verbal descriptions of physical situations and the corresponding free-body diagrams are given below. Use your understanding of Newton's laws and centripetal force to fill in the blanks. **PSYW**

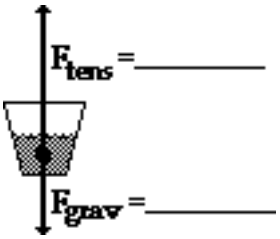
   a. A bucket of water (m=2.0 kg) is attached to a 0.80-m long string and spun in a vertical circle. The speed of the water at the top of the circular path is 3.0 m/s.

   a = _____ m/s^2, _____ (dir'n)

   F_{net} = _____ N, _____ (dir'n)

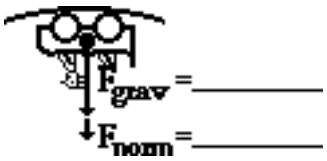
   b. A bucket of water (m=2.0 kg) is attached to a 0.80-m long string and spun in a vertical circle. The speed of the water at the bottom of the circular path is 6.0 m/s.

   a = _____ m/s^2, _____ (dir'n)

   F_{net} = _____ N, _____ (dir'n)

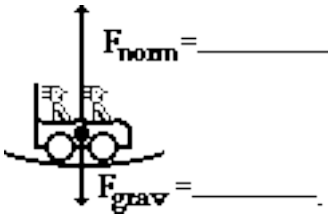
   c. A 500-kg roller coaster car is at the top of the loop on the Shockwave. The radius of the loop is 4.0 m and the speed is 8.0 m/s.

   a = _____ m/s^2, _____ (dir'n)

   F_{net} = _____ N, _____ (dir'n)

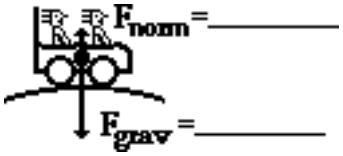
   d. A 500-kg roller coaster car is at the bottom of a loop on the Shockwave. The radius of the loop is 20 m and the speed is 24 m/s.

   a = _____ m/s^2, _____ (dir'n)

   F_{net} = _____ N, _____ (dir'n)

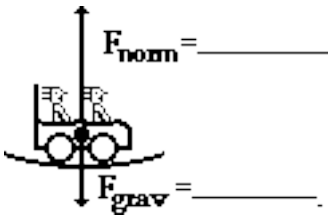
e. A 600-kg roller coaster car is at the top of a hill on the Viper. The radius of the curvature is 22 m and the speed is 14 m/s.



a = _____ m/s^2, _____ (dir'n)

F_{net} = _____ N, _____ (dir'n)

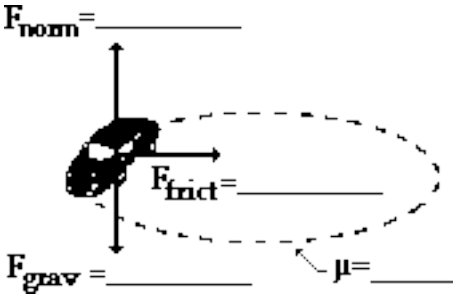
f. A 600-kg roller coaster car is at the bottom of a hill on the Viper. The radius of the curvature is 39 m and the speed is 30 m/s.



a = _____ m/s^2, _____ (dir'n)

F_{net} = _____ N, _____ (dir'n)

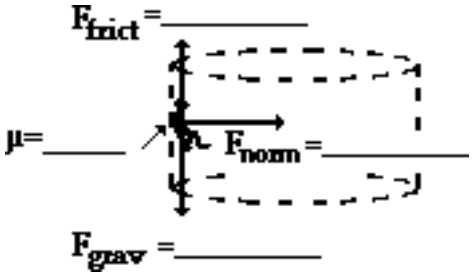
g. A 900-kg car makes a horizontal turn at 15.0 m/s around a curve with a 32.5-m radius of curvature.



a = _____ m/s^2, _____ (dir'n)

F_{net} = _____ N, _____ (dir'n)

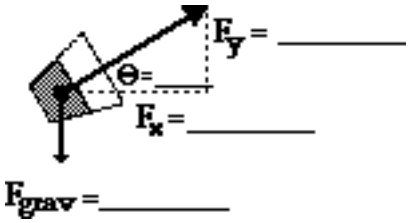
h. A 55-kg passenger on the CliffHanger barrel ride makes a turn at a speed of 6.0 m/s. The barrel radius is 3.0 meters.



a = _____ m/s^2, _____ (dir'n)

F_{net} = _____ N, _____ (dir'n)

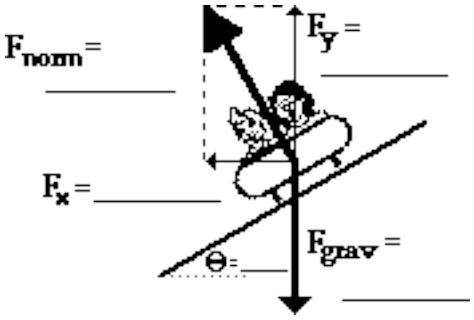
i. A 1.2-kg bucket of water is held by a string and spun in a horizontal circle with a 1.1-m radius. The speed of the bucket is 5.2 m/s.



a = _____ m/s^2, _____ (dir'n)

F_{net} = _____ N, _____ (dir'n)

j. Thelma and Louise make a turn at 22.0 m/s in their 1200-kg car. The radius of curvature of the turn is 65.0 meters.

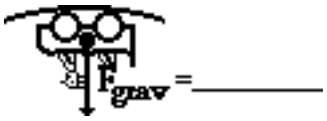


a = _____ m/s^2, _____ (dir'n)

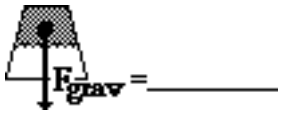
F_{net} = _____ N, _____ (dir'n)

2. Determine the minimum speed at which .... . (HINT: at this speed, the object becomes a projectile.)

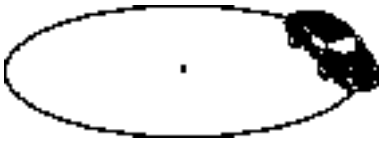
   a. ... the riders on a coaster car feel weightless at the top of a 4.0 m loop.

   b. ... the water remains in contact with the bucket bottom at the top of a 0.80-m circle.

3. The coefficient of friction between an 1125-kg car and the roadway is 0.850. Determine the maximum speed at which the car can maneuver through a curve with a radius of curvature of 25.0 meters. Begin with a free-body diagram.



4. An air-show pilot makes a vertical loop with a radius of curvature of 84.0 m. Determine the normal force acting upon the 65.2-kg body at the bottom of the loop if the air speed is 62.0 m/s. Begin with a free-body diagram.

5. A 54.0-kg roller coaster passenger is moving so fast over the crest of a hill that she is lifted off her seat and the safety bar exerts a downward force upon her body to keep her in the car. The speed of the car is 24.0 m/s and the radius of curvature is 30.0 meters. Determine the downward force applied by the safety bar. Begin with a free-body diagram.

6. The speeds of a 600-kg roller coaster car at the top of three consecutive hills are shown below. The *radii* of the hills are shown. Determine the acceleration of and net force and normal force experienced by the car at the top of each hill. **PSAYW**