Chapter 8 (mostly)

Application of Newton’s Laws: Forces: Circular Motion and Gravity
\[ \sum F = ma_{\text{centripetal}} = m \frac{v^2}{r} = m\omega^2 r \] (towards center of circle)

NOTE: It is the **sum of forces** acting on the object gives a net radially inward force for uniform circular motion.
Example 8-1:

A 1 kg ball is rotating on a flat surface with a circle of radius, R. It is connected to a 2 kg block that is suspended at the center of the table. If the speed of the ball is 1.8 m/s, what is the radius of the circle?
Example 8-2:

A car enters a curve with a radius, \( R = 75 \) m. If the coefficient of static friction between the tires and road is 0.2, what is the maximum safe speed to enter the curve?
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A toy car moves around a circular track at constant speed. It suddenly doubles its speed — a change of a factor of 2. As a result, the centripetal acceleration changes by a factor of

A. $1/4$.
B. $1/2$.
C. No change since the radius doesn’t change.
D. 2.
E. 4.
An ice hockey puck is tied by a string to a stake in the ice. The puck is then swung in a circle. What force is producing the centripetal acceleration of the puck?

A. Gravity  
B. Air resistance  
C. Friction  
D. Normal force  
E. Tension in the string
Example 8-3: Circular motion and gravity 1

A mass, \( m \), hangs at the end of a string of length, \( L = 1.2 \text{ m} \). The mass is rotating in a conical pendulum with \( \omega = 3 \text{ rad/sec} \). Find the angle that the mass makes with the vertical.
Vertical circles: Hills, roller coaster

At the bottom:

\[ \sum F_r = ma_c = m \frac{v^2}{r} = N - mg \]
Vertical circles: Hills, roller coaster

At the top:

\[ \sum F_r = ma_c = m \frac{v^2}{r} = N + mg \]

\[ a_{\text{centripetal}} \]
Example 8-4: Circular motion and gravity 2

A 250 kg roller coaster car enters a 20 m diameter loop at 15 m/s. Find the normal force on the car and the minimum velocity the car must have at the top of the loop in order to remain on the track.
A car turns a corner on a banked road. Which of the diagrams **could** be the car’s free-body diagram?

A.  
B.  
C.  
D.  
E.
A physics textbook swings back and forth as a pendulum. Which is the correct free-body diagram when the book is at the bottom and moving to the right?

A.  
B.  
C.  
D.  
E.  

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A roller coaster car does a loop-the-loop. Which of the free-body diagrams shows the forces on the car at the top of the loop? Rolling friction can be neglected.
Universal gravitation:

\[ F_{\text{Earth-moon}} = -F_{\text{moon-earth}} \]

\[ F_{\text{gravity}} = G \frac{m_1 m_2}{R^2} \]

where: \( G = 6.67 \times 10^{-11} \) N-m\(^2\)/kg\(^2\)
Universal gravitation:

\[ F_{\text{gravity}} = G \frac{m_1 m_2}{R^2} \]

where: \( G = 6.67 \times 10^{-11} \text{ N-m}^2/\text{kg}^2 \)
Example 8-6:

The International Space Station (ISS) orbits the earth at a distance of 415 km above the surface. What is the orbital velocity of the ISS?

\[ M_E = 5.98 \times 10^{24} \text{ kg}, \quad R_E = 6.4 \times 10^3 \text{ km} \]