7.9: Applications of Newton's Laws (Summary)

Key Terms

banked curve	curve in a road that is sloping in a manner that helps a vehicle negotiate the curve
centripetal force	any net force causing uniform circular motion
Coriolis force	inertial force causing the apparent deflection of moving objects when viewed in a rotating frame of reference
drag force	force that always opposes the motion of an object in a fluid; unlike simple friction, the drag force is proportional to some function of the velocity of the object in that fluid
friction	force that opposes relative motion or attempts at motion between systems in contact
ideal banking	sloping of a curve in a road, where the angle of the slope allows the vehicle to negotiate the curve at a certain speed without the aid of friction between the tires and the road; the net external force on the vehicle equals the horizontal centripetal force in the absence of friction
inertial force	force that has no physical origin
kinetic friction	force that opposes the motion of two systems that are in contact and moving relative to each other
noninertial frame of reference	accelerated frame of reference
static friction	force that opposes the motion of two systems that are in contact and are not moving relative to each other
terminal velocity	constant velocity achieved by a falling object, which occurs when the weight of the object is balanced by the upward drag force

Key Equations

Magnitude of static friction	$f_s \leq \mu_s N$	(7.9.1)
Magnitude of kinetic friction	$f_k = \mu_k N$	(7.9.2)
Centripetal force	$F_c = m\frac{v^2}{r} = mr\omega^2$	
Ideal angle of a banked curve	$\tan\theta = \frac{v^2}{rg}$	(7.9.3)
Drag force	$F_D = \frac{1}{2}C\rho A v^2$	(7.9.4)
Stokes' law	$F_s = 6\pi r\eta v$	(7.9.5)

Summary

6.1 Solving Problems with Newton's Laws

- Newton's laws of motion can be applied in numerous situations to solve motion problems.
- Some problems contain multiple force vectors acting in different directions on an object. Be sure to draw diagrams, resolve all force vectors into horizontal and vertical components, and draw a free-body diagram. Always analyze the direction in which an object accelerates so that you can determine whether $F_{net} = ma$ or $F_{net} = 0$.
- The normal force on an object is not always equal in magnitude to the weight of the object. If an object is accelerating vertically, the normal force is less than or greater than the weight of the object. Also, if the object is on an inclined plane, the normal force is always less than the full weight of the object.
- Some problems contain several physical quantities, such as forces, acceleration, velocity, or position. You can apply concepts from kinematics and dynamics to solve these problems.

6.2 Friction

- Friction is a contact force that opposes the motion or attempted motion between two systems. Simple friction is proportional to the normal force N supporting the two systems.
- The magnitude of static friction force between two materials stationary relative to each other is determined using the coefficient of static friction, which depends on both materials.
- The kinetic friction force between two materials moving relative to each other is determined using the coefficient of kinetic friction, which also depends on both materials and is always less than the coefficient of static friction.

6.3 Centripetal Force

- Centripetal force $\vec{F}_c$ is a "center-seeking" force that always points toward the center of rotation. It is perpendicular to linear velocity and has the magnitude

$$F_c = ma_c. \tag{7.9.6}$$

- Rotating and accelerated frames of reference are noninertial. Inertial forces, such as the Coriolis force, are needed to explain motion in such frames.

6.4 Drag Force and Terminal Speed

- Drag forces acting on an object moving in a fluid oppose the motion. For larger objects (such as a baseball) moving at a velocity in air, the drag force is determined using the drag coefficient (typical values are given in Table 6.2), the area of the object facing the fluid, and the fluid density.
- For small objects (such as a bacterium) moving in a denser medium (such as water), the drag force is given by Stokes' law.

Contributors and Attributions

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