EXAM 2 Review

Chapters 4, 5, 6, 7

Chapter 4 - Newton's Laws

- **First Law** - an object will not change its motion unless a force acts on it.

$$\sum F = 0$$

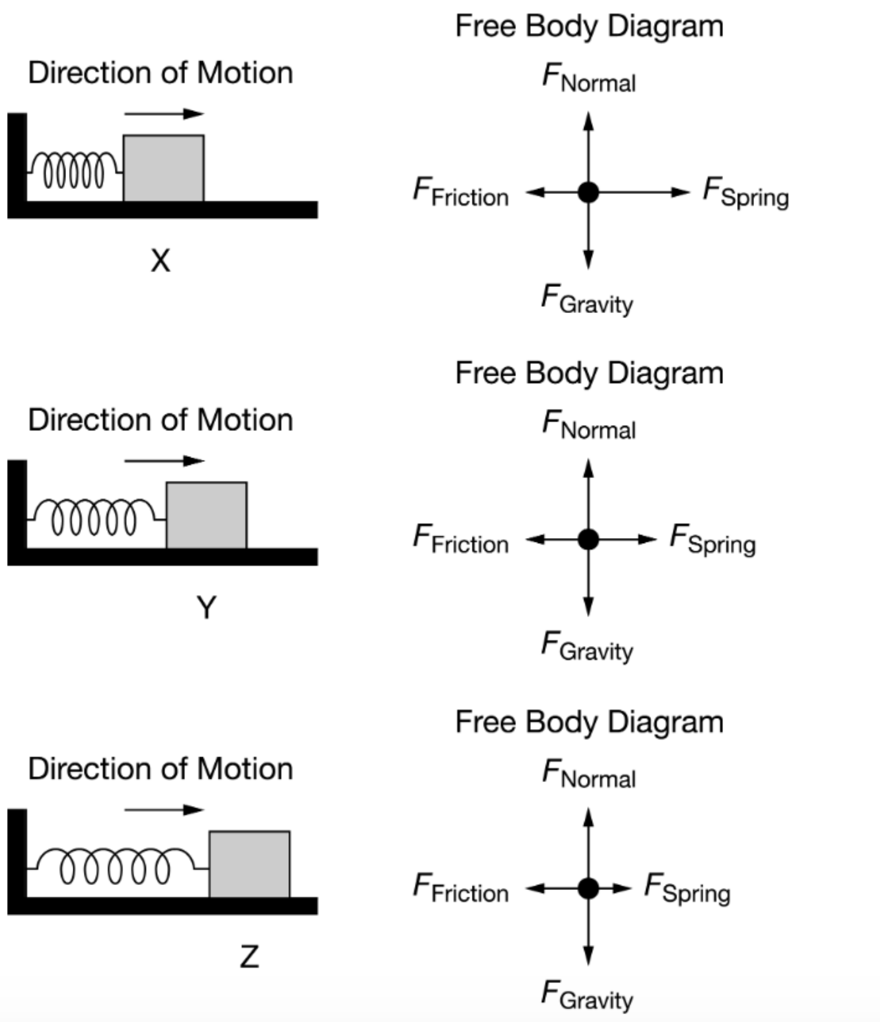
- **Second Law** - the force on an object is equal to its mass times its acceleration.

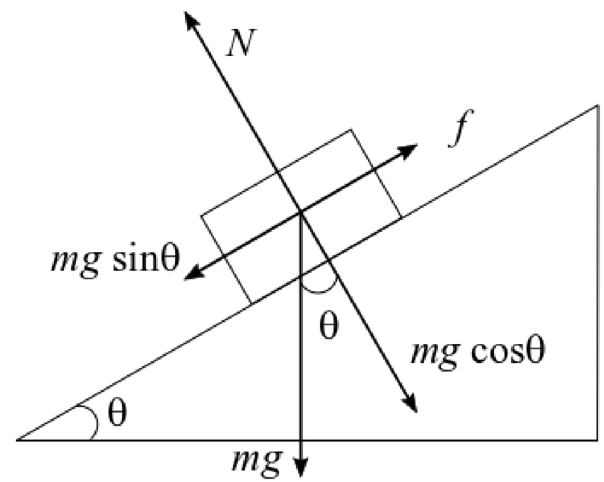
$$F = ma$$

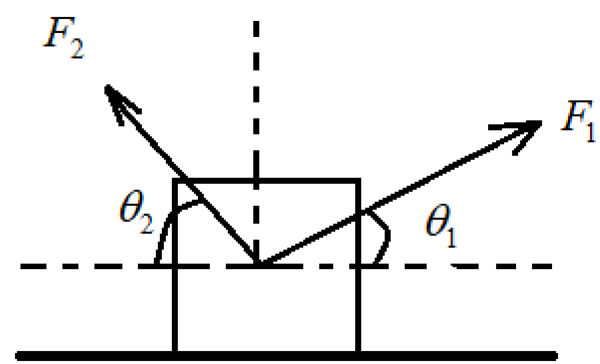
- **Third Law** – for every action, there is an equal an opposite reaction.

$$F_{A\ on\ \boldsymbol{B}} = -F_{B\ on\ A}$$

Free Body Diagrams



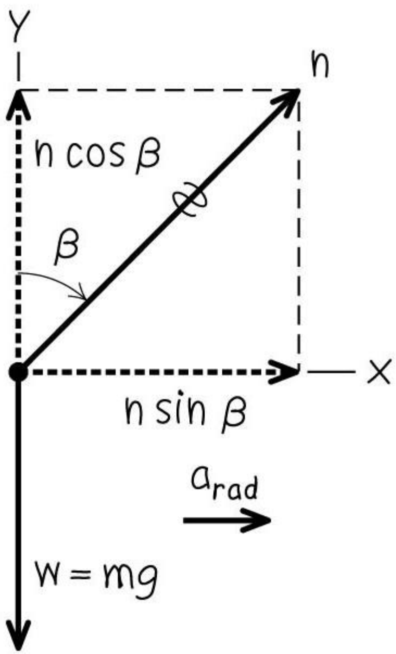




CH5 - Applications of Newton's Laws

- Newton's 1st: $\sum F = 0$ (equilibrium)
- Newton's 2nd: $\sum F = ma$ (dynamic)
- Force of Friction: $f_k = \mu_k n$
- Force in circular motion $F = ma_{rad} = m\frac{v^2}{R} = m\left(\frac{4\pi^2 R}{T}\right)$
- Banked curve angle: $\beta = \tan^{-1}\left(\frac{a_{rad}}{g}\right) = \tan^{-1}\left(\frac{v^2}{gR}\right)$

Banked Curve…



- The centripetal acceleration of the car in the x-direction: $\mathbf{a_{rad} = v^2/R}$, and none in y-direction. From Newton's second law:

$$\sum F_x = n \sin \beta = \mathrm{m}a_{rad}$$

$$\sum F_y = n \cos \beta \ - \mathrm{mg} = 0$$

- From second equation, n = mg/cosβ
- Plugging into first equation, we get

$$\left(\frac{mg}{cos\beta}\right) \sin \beta = \ \mathrm{m}a_{rad} \quad \Rightarrow \quad g\ tan\beta = \ a_{rad} = \frac{v^2}{R}$$

- Thus, we arrive at an expression for banked angle:

$$\beta = \ \tan^{-1}\left(\frac{a_{rad}}{g}\right) = \ \tan^{-1}\left(\frac{v^2}{gR}\right)$$

CH6 – Work and Kinetic Energy

- Hook's Law: $$\boxed{F = kx}$$ $\left[\left(\frac{kg}{s^2}\right) \cdot m = N\right]$
- Work: $$\boxed{W = Fx = \int F\,dx = \frac{1}{2}\,kx^2}$$ [N·m = J]
- Kinetic Energy: $$\boxed{K = \frac{1}{2}\,mv^2}$$ [N·m = J]
- Power: $$\boxed{P = \frac{W}{\Delta t} = F\frac{\Delta x}{\Delta t} = F \cdot v}$$ $\left[\frac{J}{s} = \frac{N \cdot m}{s} = W\right]$

Chapter 7 – Conservation of Energy

- Potential Gravitational Energy: $\Delta U_{grav} = mgh$
- Potential Elastic Energy: $\Delta U_{el} = \frac{1}{2}\mathrm{k}x^2$

- Conservation of Energy:

$$\Delta E = \left(\Delta K_f + \Delta U_f\right) - \left(\Delta K_i + \Delta U_i - W_f\right) = 0$$

- Force via Potential Energy:

$$F(x) = -\frac{d}{dx}U(x) = -\left(\frac{\delta U}{\delta x}\hat{\imath} + \frac{\delta U}{\delta y}\hat{\jmath} + \frac{\delta U}{\delta z}\hat{z}\right)$$