Example

- No friction
- Sliding object
- How do $\vec{F}$ at bottom?
  - $a$ constant
- Difficult problem using force!!

\[ W_1 = 0 \quad \text{N L dcl} \]
\[ k_2 + u_2 = k_1 + u_1 \]
\[ \frac{1}{2} m v^2 + 0 = 0 + \text{mg} R \]
\[ v_f = \sqrt{2gR} \]
If there is friction, it would be less!

Example

Pull string to side with force $P$.
Slowly: $\Delta E = 0$

\[ P = T \sin \theta \quad \{ P = \text{w} \tan \theta = \text{mg} \tan \theta \} \]
\[ W = T \cos \theta \]

work done = $\int \text{force} \cdot \text{distance} \, \text{d}x$

\[ \Delta w = k \Delta \theta \quad \text{arc length} \]
\[ W = \int \text{work} \cdot \text{cos} \theta \, \text{d} \theta \]
\[ = \text{WR} \sin \text{c} \, \text{d} \theta \]
\[ = \text{WR} (1 - \cos \theta) \]

\[ W_{\text{total}} = W_T + W_R = \Delta K + \Delta U = \Delta E \]

\[ W_T = 0 \quad \text{T L dcl} \]
\[ \Delta K = 0 \quad \text{Sunny moves slower} \]
\[ W_T = \Delta U = \text{mg} \Delta y \]
\[ \Delta y = R (1 - \cos \theta) \]
\[ W_p = W_R (1 - \cos \theta) \]
Lecture 14, Blackboard #2

Example
- No friction
- Sliding Object
- Which is F at bottom?
- S constant

**Difficult problem using force!!**

\[ W_N = 0 \quad N \perp \text{decel} \]
\[ F_k + F_a = F_{\text{tot}} \]
\[ \frac{1}{2} m v^2 + 0 = 0 + mgR \]
\[ F = \sqrt{2gR} \]
If there is friction, \( W \) would be less!

Block on Incline
- More a distance D
- \( v \) at \( t = 0 \)
- Find \( W \) at \( t = t \)
- \( W_D = (m g \sin \theta) \cdot D \)
- \( W_f = \int F \cdot \overline{FD} = FD \)
- \( K_F = \frac{1}{2} m v^2 \), \( K_i = 0 \)
- \( K_F - K_i = W_{\text{Net}} \)
- \( \frac{1}{2} m v^2 = 0 = FD - mgD(s \theta + u \cos \theta) \)
- \( v = \sqrt{\frac{2FD - 2gD(s \theta + u \cos \theta)}{m}} \)
- If \( \left[ \frac{2FD - 2gD(s \theta + u \cos \theta)}{m} \right] = 0 \)
- If \( \left[ \right] < 0 \quad ?? \Rightarrow u = 0 \)
**Conservative Forces**

Given \( \text{Kinetic} + \text{Potential Energy} = \text{Great} \)

**Sprung:** \( E = K + U \) \( \text{[Constant]} \rightarrow \text{Conservative} \)

**1st:** \( E = K + U \) \( \text{[Constant]} \rightarrow \text{Conservative} \)

**Integrate general requirements for a force to be conservative:** Assume \( F \) is a function only \( f \) of position.

**Definition:** 
\[ \mathbf{F} \text{ is conservative} \]

\[ \frac{\delta W}{\delta x} = F \text{ for every two points.} \]

**Example**

\[ E = K + U \]

\[ E_1 = 0 \]

\[ F = \frac{1}{2} \left[ m_1 + m_2 \right] \frac{v_1^2}{2} - m_1 g \left( x_2 - x_1 \right) \]

\[ E_2 = ? \]

\[ x_2 - x_1 = 0.75 \text{m} \]

\[ m_1 = 206 \]

\[ m_2 = 100 \]

\[ u_1 = 10 \]

\[ v_2 = ? \]

\[ v_2 = \sqrt{2m_1 g (x_2 - x_1)} = \sqrt{2 \times 100 \times 10 \times 0.75 \text{m/s}^2} \]

\[ = 10 \text{m/s} \]

**Conservation of Energy**

Cases where \( K + U \) \( \text{[Not constant]} \)

\( \rightarrow \text{Competitive forces} \)

\[ \Delta E + \Delta U + \Delta (\text{All others}) = 0 \]

**Forms of Energy**

- Thermal energy
- Electrical
- Chemical
- Nuclear
- Mechanical

Laws of Conservation of Energy

Helps in all domains. Even, why Newton's laws fail!
Conservation Forces

Gravity + Kinetic = Potential Energy = Constant

First Law of Conservation: E = K + U

What are general requirements for a force to be conservative? Assume F is a function only of position.

Definition: F is conservative if W_{P_1, P_2} = W_{P_2, P_1} for any two paths.

Potential Energy

P_1 \rightarrow P_2 \rightarrow P_1

If F is conservative, total W = 0

W_{P_1, P_2} + W_{P_2, P_1} = 0

\int_{P_1}^{P_2} F \cdot dr + \int_{P_2}^{P_1} F \cdot dr = \int_{P_1}^{P_2} F \cdot dr - \int_{P_2}^{P_1} F \cdot dr = 0

Conservation of Energy

Gravitational Potential Energy = Constant

Conservation of Kinetic Energy

Friction: No!!

Work = 0

Always opposite motion. Work \Rightarrow Heat/Dissipate.
Lecture 14, Blackboard #5

**Mechanical Energy**
- \( \Delta KE = \text{Work done by Force} \)
- \( k_s - k_i = \int_{P_i}^{P_f} F \, dt \)
- \( K_s + U_{i} = U_{s} + U_{i} \)
- \( \text{Total Mech Enrgy} = \text{Constant} \)

**Pot Energy: Gravity (non Earth)**
- \( F = -mg \)
- \( \int_{P_i}^{P_f} F \, dt + U(P) \)
- \( \int_{P_i}^{P_f} F \, dt = -mg \int_{P_i}^{P_f} \, dt \)

\( U(P) = -mgz - \frac{1}{2} \alpha \beta \)

**Potential Energy & Conservation of Forces**
- \( U(P) = \text{Pot Energy at Reference Point} \)
- \( U(R) = \text{Pot Energy at General Point} \)
- \( P = \text{Reference Point} \)
- \( P' = \text{General Point} \)

\( U(P) = -\int_{P_i}^{P_f} F \, dt + U(P') \)

\( \Delta U = U(P) - U(P') = -\int_{P_i}^{P_f} F \, dt \)

\( \text{Nature's work done by the force between } P \text{ and } P' \)

\( U(R) \text{ Drops Out! Always!} \)

Choose \( U(P) = 0 \)!