Lecture 16 - Review 2 - 3.7

Tuesday, March 7, 2023 9:30 AM

Lecture 2 is all about models to predict movement

Lecture 3 uses calculus to derive the Kinematics equations
- Creates powerful models for movement in one dimension

Lecture 4
- Object falls at the same speed in G independent of mass
- Takes the same time to go up as it does to go down
- Speed up is same as speed down at same displacement

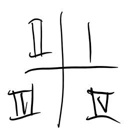
Lecture 5
- setup kinematics equations for constant acceleration
- a(t) = a
- v(t) = v_0 + a*t
- x(t) = x_0 + v_0 * t + (1/2) * a * t^2

Lecture 6
- Vectors
    - magnitude and direction
- Unit vectors
- Vector notion
- Vectors create triangles
    - r (hypot), x(adj), y(opposite)
    - SohCahToa
- Helps solve projectile motion

Lecture 7
- Vector algebra
    - add everything in the individual components (x,y,z)
- Explored 2D motion
    - Ballrs rolling from table hit ground at same time

$$\begin{pmatrix} a_1 \\ a_2 \end{pmatrix} + \begin{pmatrix} b_1 \\ b_2 \end{pmatrix} = \begin{pmatrix} a_1 + b_1 = c_2 \\ a_2 + b_2 = c_2 \end{pmatrix}$$

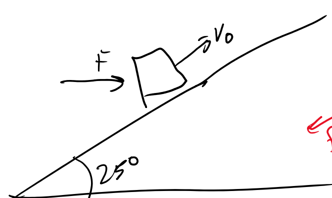
Lecture 8
- Uniform Circular Motion
    - vectors can change direcrion while having same magnitude
        - acceleration can change velocities without changing speed
    - circular motion results in centripetal acceleration
    - Motions in rotating frames become pretty complicated



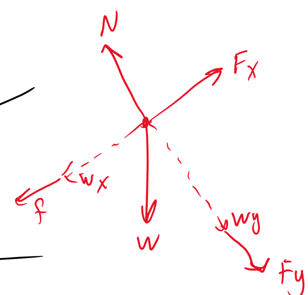
Lecture 9
- We can express x,v,a in 1d as functions of time.
- special case of circular motion
- quadrants

Lecture 10
- Forces
- Newton's first law
    - force is needed to change an objects state of movement
- Newton's second law
    - F = m*a
- Third law
    - Equal and opposite reactions
    - Forces come in pairs
    - Push on wall, wall pushes back

Lecture 12
- Friction
    - Static
    - Kinematic
    - Molecular level
- Free Body Diagrams



Changing Forces or Paths



const F, Straight Path

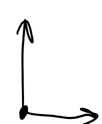
Lecture 13
- Newton's laws
- Normal Force

Lecture 14
- Work
- Perpendicular Forces means there's no work

$$W = \int_a^b F(s) \cdot ds \qquad W = Fs \cdot \cos\theta \quad s = \text{distance}$$

$$W_{net} = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 \leftarrow \text{change in Energy}$$

$$W_{net} = K - K_0$$


= No Work

Lecture 15
- Work = energy transferred to or from an object
    - can be negative!!
- We call the ability of an object to do work 'Energy'
- Power = Work / Time
- Kinematic Energy
- Gravitational Potential Energy
- Energy is conserved

$$K = \frac{1}{2}mv^2 \qquad U_{grav} = m \cdot g \cdot h$$

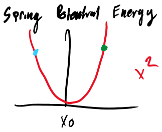
$$P = W/t$$

if W is greater, so is P

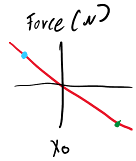
If t is Smaller, P is larger

Lecture 16
- Conversions between kinetic and potential energy is converved
- Springs can store energy

Spring Potential Energy



Force (N)



$$U_{spring} = \frac{1}{2}k(x - x_0)^2$$

$$F_{spring} = -k(x - x_0)$$

Hooke's Law

$$F = -Kx$$

$$W = 1kg \cdot 9.8 m/s^2 \approx 10 N$$

$$\Delta x = -1cm = -0.01m$$

$$\frac{-F}{} = \frac{10N}{} = \boxed{1000 N/m = K}$$

$W = 1kg \cdot 9.8 m/s \approx 10 ...$

$\Delta x = -1cm = -0.01m$

$K = \frac{-F}{\Delta x} = \frac{10N}{0.01} = \boxed{1000 N/m = K}$

$F_{spring} = -k(x - x_0)$

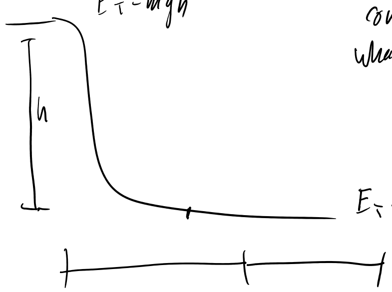
$F_x = -\frac{du}{dx}$

Conservation of Energy
- If you add up all the energy in a system you get a number
- Doesn't matter at what time you add it up, it will always be the same
- Work done against energy is "stored" as potential energy that you can get back
- Same thing with springs

$$U_{grav_0} + U_{spring_0} + K_0 = U_{grav} + U_{spring} + K$$

Conservation of Energy and Work-Energy theorem are tools
- You can use these tools to find velocity
- If you put equations from the work-energy theorem in the right form you can find acceleration
- You can use velocity and acceleration to solve your other kinematic problems

$E_T = mgh$

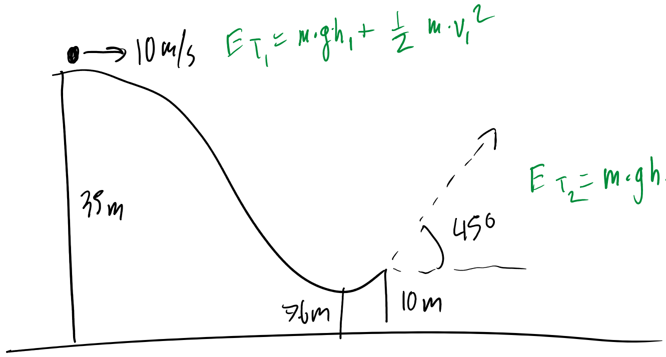


$E_T = 0$

Skier problem - goes downhill, comes to stop at bottom. what do we know about friction and air resistance?

$\Delta E = -mgh = W_{friction} + W_{air}$

car goes off ramp w/o friction. How fast is it going when it leaves ramp?



$E_{T_1} = m \cdot g \cdot h_1 + \frac{1}{2} m \cdot v_1^2$

$E_{T_2} = m \cdot g h_2 + \frac{1}{2} m V_2^2$

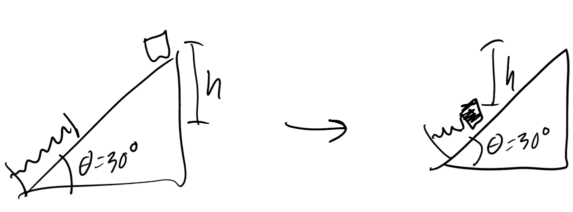
$E_{T_1} = E_{T_2}$; solve for V_2

$W = \Delta E_{kin}$

$m \cdot g(h - h_2) = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

How fast when it hits the ground

$\cancel{m} \cdot g \cdot h + \frac{1}{2} \cancel{m} \cdot v_i^2 = \frac{1}{2} \cancel{m} \cdot v_f^2$ m's all cancel



can be compressed 3.0cm by force 270N

block = 12kg

spring compresses 5.5cm.

How How was the block?

Conserve forces

$E_{T_0} = mgh$ $E_{T_f} = \frac{1}{2} K x^2$

Set equal, solve for h

$h = \frac{1}{2} \frac{K}{m \cdot g} \cdot x^2$

Find K using Hooke's Law

$F = -K \Delta x$

$K = \frac{270 N}{2 cm} = \frac{270 N}{0.02 m} = 27000 \frac{N}{m}$