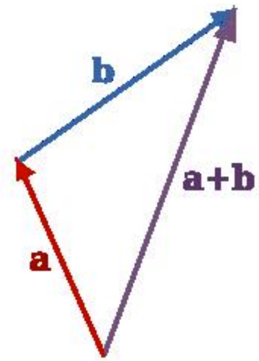
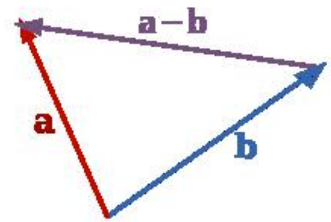
Quick review
of select topics based on student inquiries

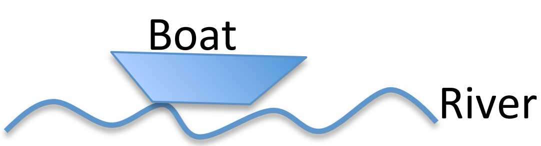
-AP Phy C Mechanics

Relative Velocity

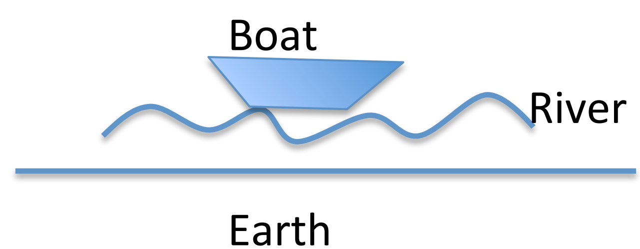




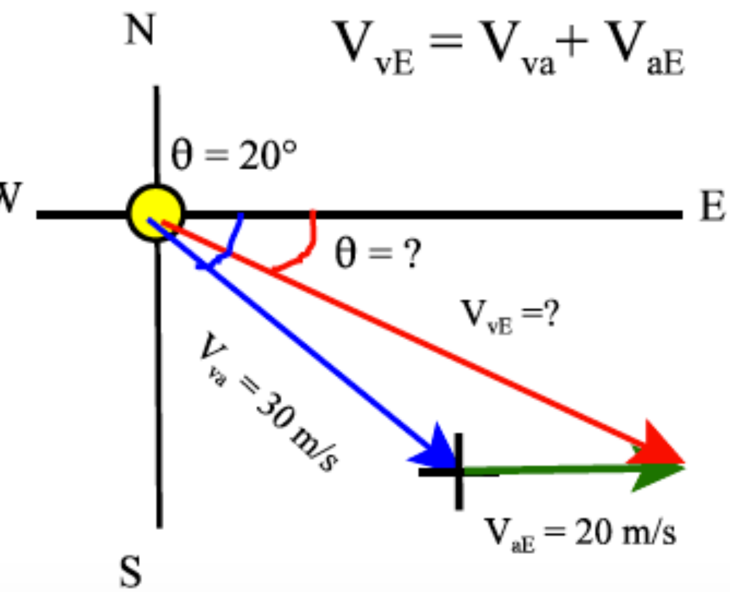
Case 1 –
2 moving objects compared to each other



Case 2 –
2 moving objects compared to one common medium

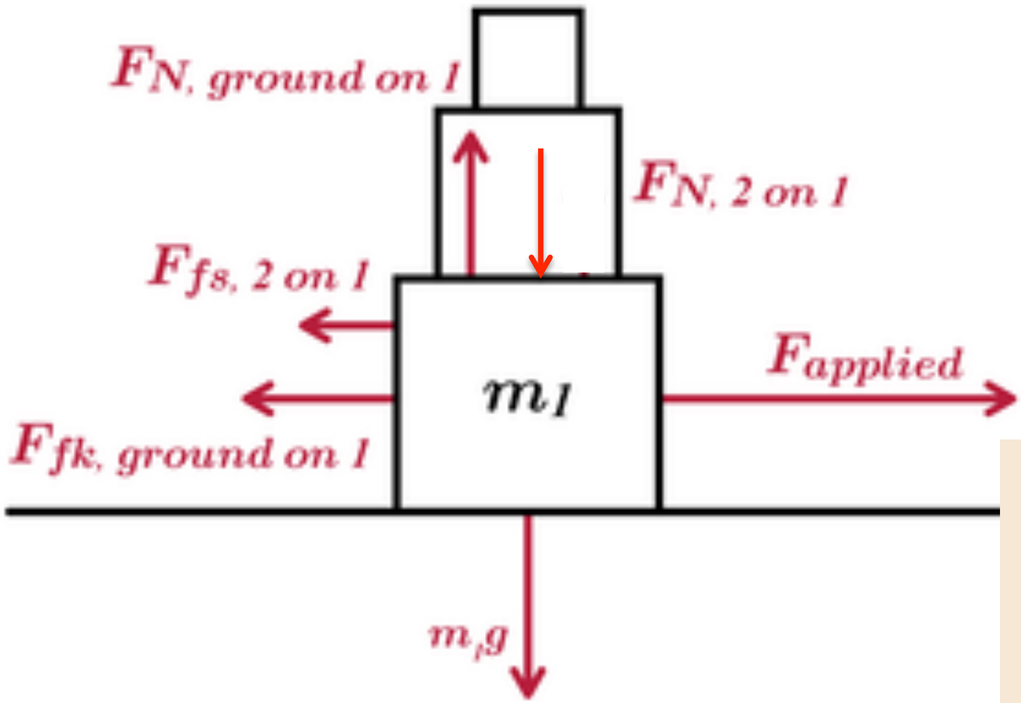


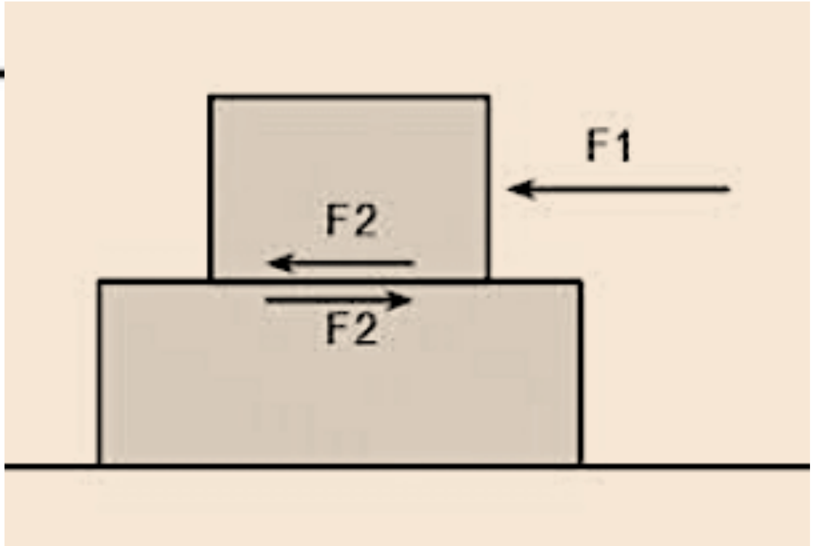
A large panel van has a velocity of 30 m/s at 20° S of E **in still air.** A gust of wind of 20 m/s due East relative to the Earth strikes the van. What is the resultant velocity of the van relative to the Earth, during the gust?



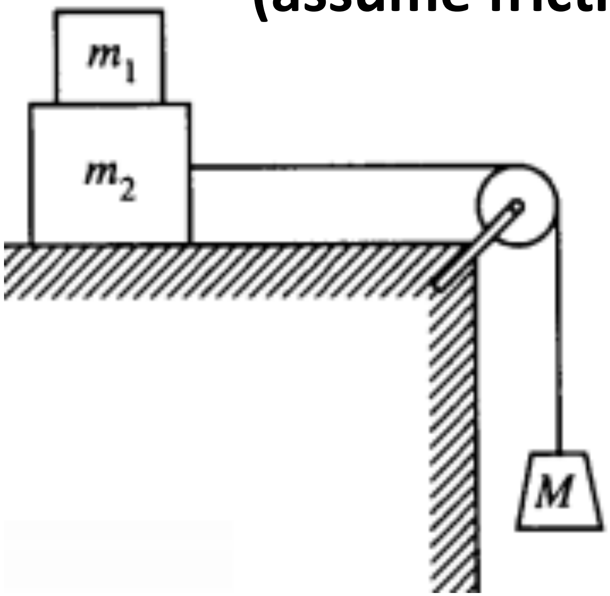
Ans : 49.2 m/s 12^0 S of E
Go over step by step solution under Rel Vel review under today's classwork

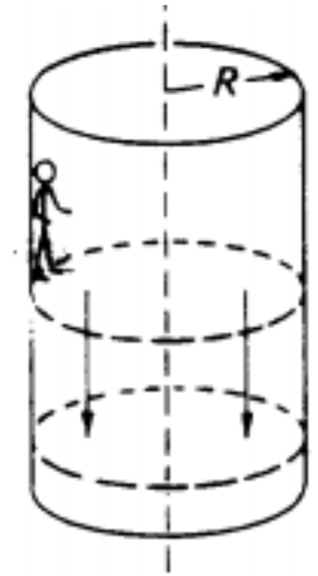
Forces – pay attention to directions

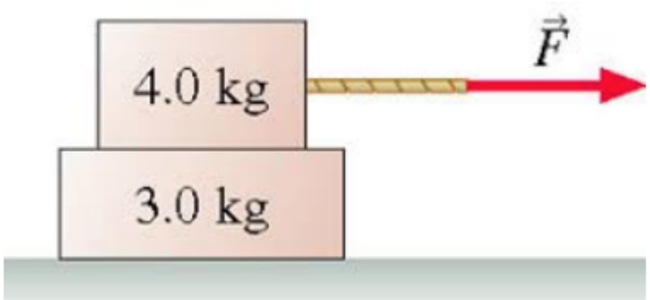




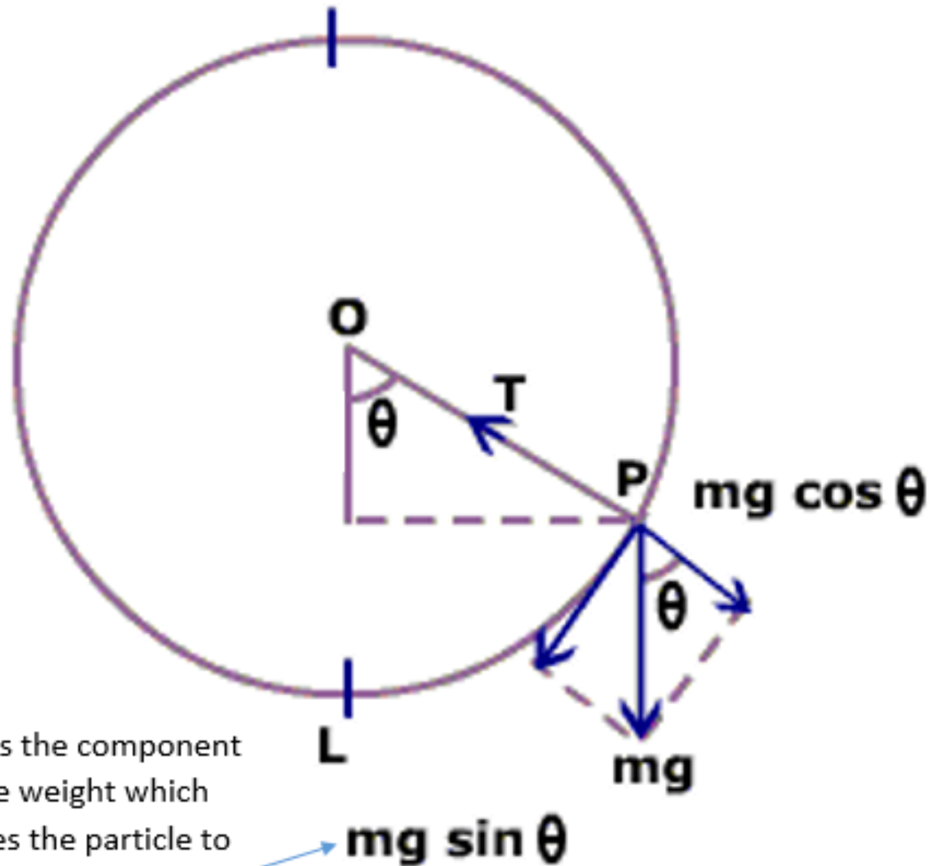
Draw free body diagram (FBD) for every object in these arrangements (assume friction exists on all interfaces)





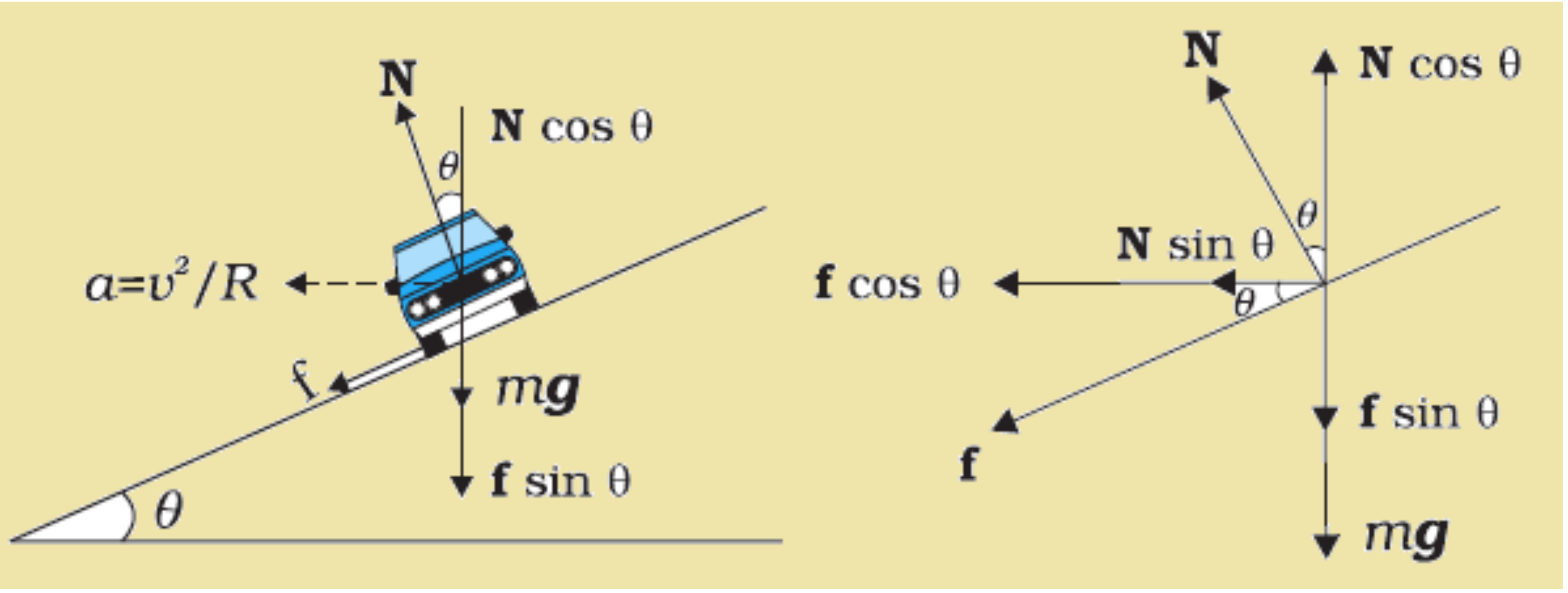


Circular motion



This is the component of the weight which causes the particle to slow down or speed up

Banking Problem



W.E.T. (Work-Energy Theorem)

- The total work done on an object equals the change in the object's kinetic energy and/or gravitational potential energy.

$$W_{total} = \Delta E_K$$

$$W_{total} = E_{K2} - E_{K1}$$

$$F\Delta\vec{d} = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

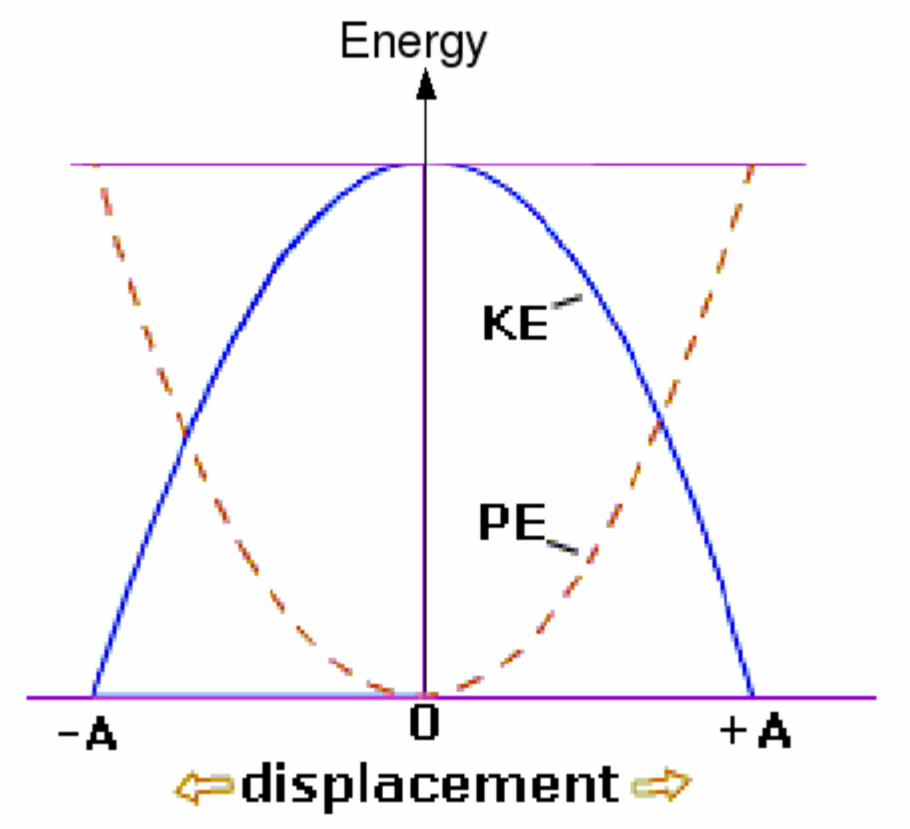
$$W_{total} = \Delta E_g$$

$$W_{total} = E_{g2} - E_{g1}$$

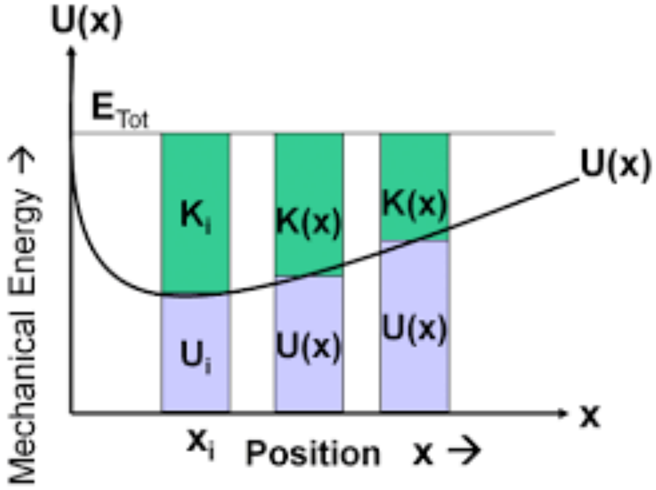
$$F\Delta\vec{d} = mgh_2 - mgh_1$$

$$\Delta E_k = -\Delta E_g$$

PE Curves



Energy
KE
PE
-A
0
+A
displacement



U(x)
E_Tot
Mechanical Energy →
K_i
K(x)
K(x)
U(x)
U_i
U(x)
U(x)
x
x_i
Position x →

F = - (attractive) ; + (repulsive)

PE of a spring

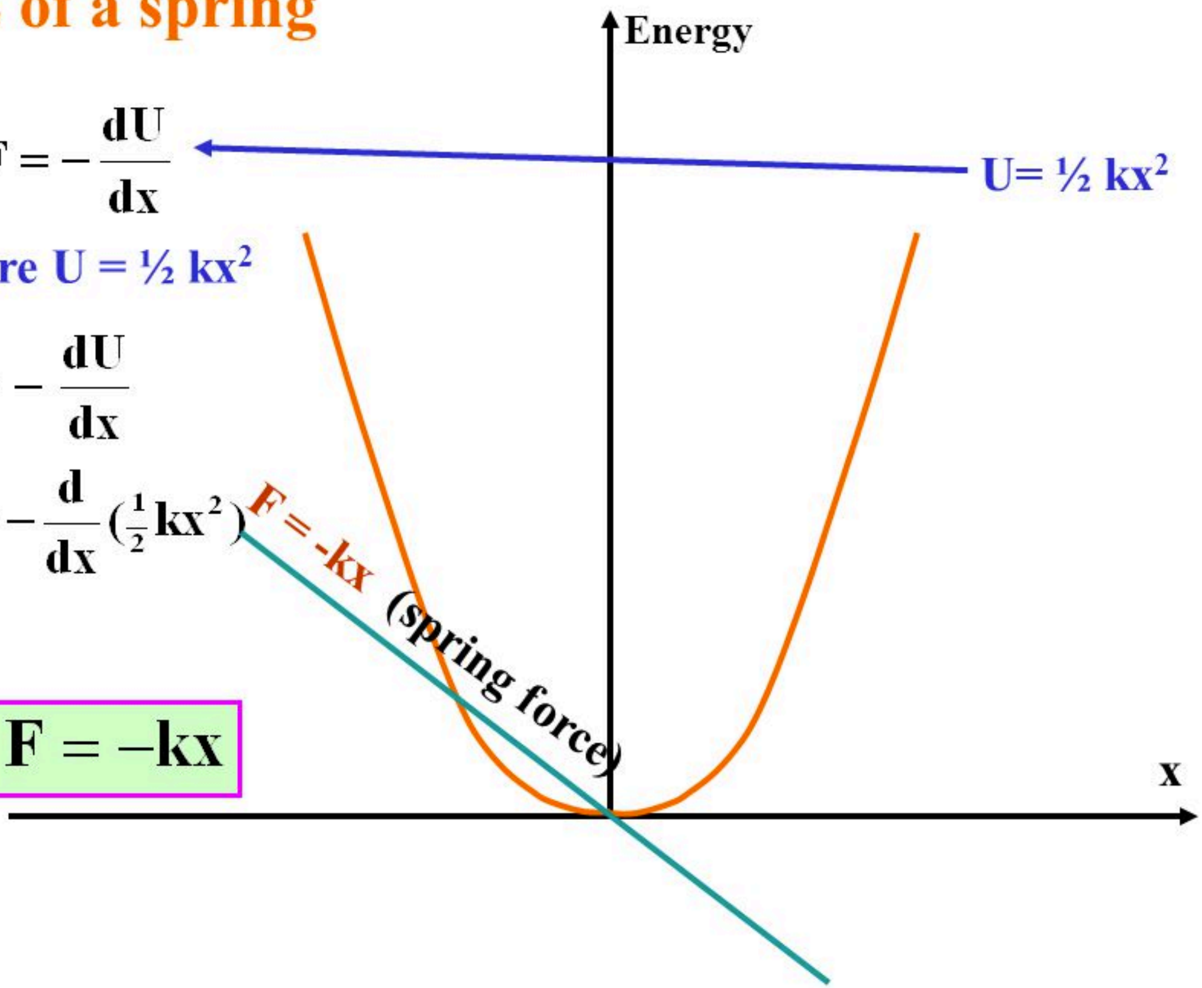
$$F = -\frac{dU}{dx}$$

here $U = \frac{1}{2} kx^2$

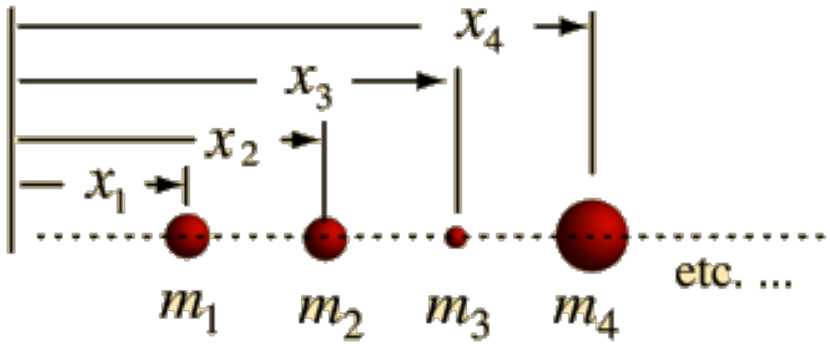
$$\text{so } F = -\frac{dU}{dx}$$

$$= -\frac{d}{dx}\left(\frac{1}{2}kx^2\right)$$

$$\therefore F = -kx$$



CoM and Momentum Conservation



$$x_{cm} = \frac{\sum_{i=1}^{N} m_i x_i}{M}$$

Take derivative to get the velocity of the center of mass. (second derivative for ac c)

- If CoM does not move because of NO external force, Momentum is Conserved.
- If CoM moves then Change in Momentum

Extend time of collision

$$Impulse = F_{average}\Delta t = m\,\Delta v$$

Reduce average impact force

For a given change in momentum, the impulse stays constant.

Rotation

- Constant angular acceleration equations
- Moment of Inertia

- point masses MR^2

- several point masses add them all

$M_1R_1^2 + M_2R_2^2 + \ldots\ldots\ldots$

- extended mass (solid object – take integral)

$$I = \int_{-L/2}^{L/2} r^2 \frac{M}{L} dr = \frac{M}{L} \frac{r^3}{3} \Big|_{-L/2}^{L/2} = \frac{M}{3L} \left[\frac{L^3}{8} - \frac{-L^3}{8} \right]$$

Mass of intinitesmal length dr :

$$dm = \frac{M}{L} dr$$

$$I_{cm} = \frac{1}{12} ML^2$$

- Composite extended masses (eg: disk attached to cylidner) – Add all the individual Moment of Inertias

Rotation- most problems solved using rxF = Iα

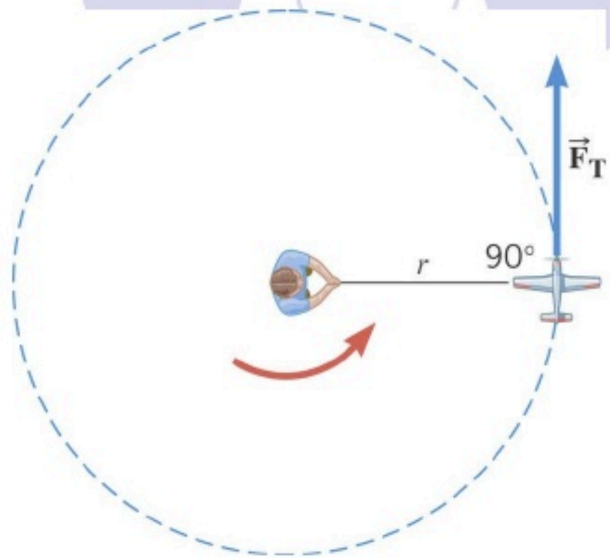
Newton's Second Law for Rotational Motion About a Fixed Axis

$$F_T = ma_T$$

$$\tau = F_T \times r \qquad a_T = r\alpha$$

$$\frac{\tau}{r} = mr\alpha$$

$$\tau = I\alpha$$

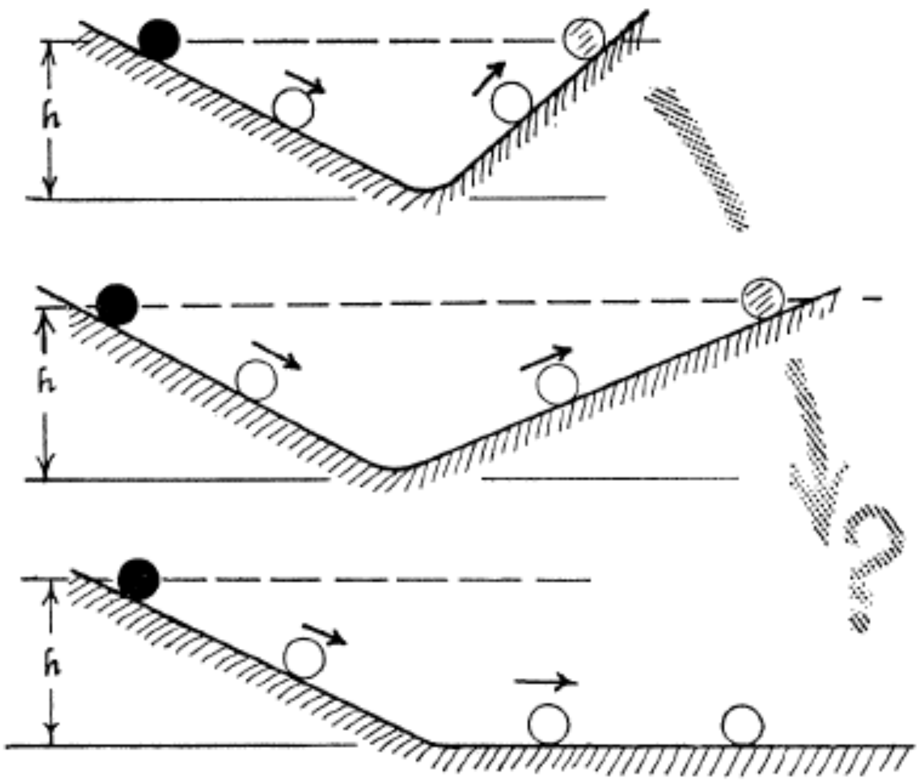


Moment of Inertia, $I = kmr^2$

k depends on shape and axis

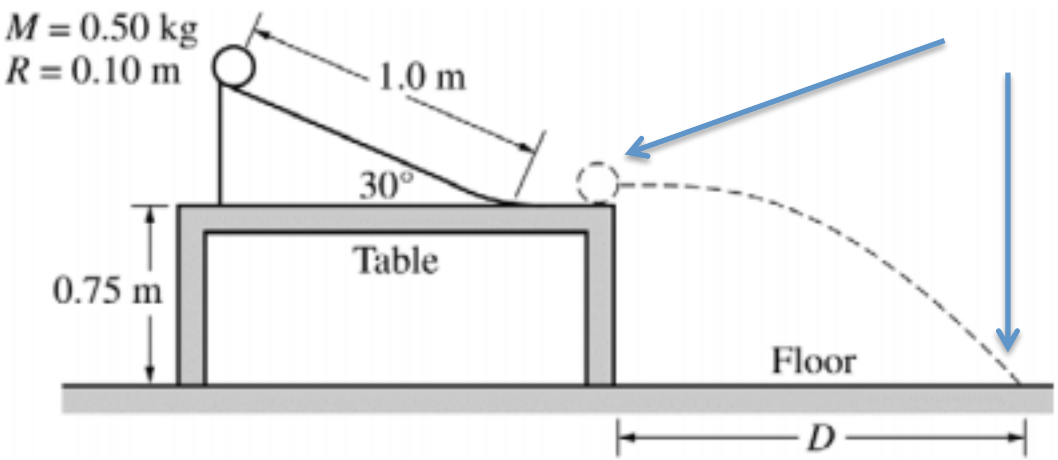
Rolling

- Friction acts opposite to how the object wants to slide.



Rolling - NSL

- Object rolling continues to roll unless there is opposing torque to decelerate and stop it.



$KE_{rotational}$ and angular velocity same unless there is drag to oppose the existing rotation

Gravitation

- Remember U at infinity = 0
- So U at any other position is negative
- ONLY for a circular orbit use

  $mv^2/r = GMm/r^2$ which would give

  TME = K +U = -GMm/2r
- Although one can generalize (not necessarily using mv^2/r – no need to know the proof)

  TME for elliptical = -GMm/2a
- To reach one orbit to another you need to do work done on the satellite

  WD = Change in TME if placed on orbit and revolving.

  WD for just lifting to another level is = - change is U alone
- Escape velocity – escape from any gravitational effects of a planet
- Use conservation of L to find velocity around elliptical.

Oscillations

Remember for SHM you need restoring forces to bring the object back to equilibrium

- At Equilibrium Forces are balanced.

  K =Max, U= 0

- At extremes k = 0, U = max

Start from Newton's 2nd law and bring it to SHM equation form, compare to find w^2. Then you should be able to find T, f, Max displacement etc. Do the worksheets again if in doubt.

$$a = \frac{d^2x}{dt^2} = -\omega^2 x$$

Statics

- Only 3 rules
  - $\Sigma F_x = 0$
  - $\Sigma F_y = 0$
  - $\Sigma \tau = 0$
- You can choose any pivot point for $\Sigma \tau = 0$

But the point with most unknown forces makes the best choice.