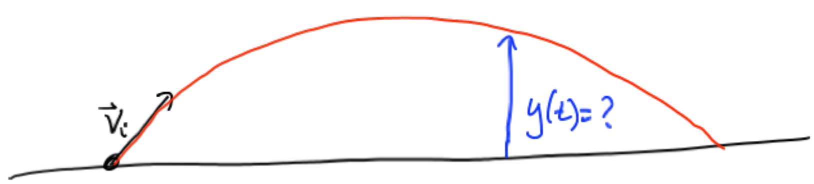
November 5

Get Clickers and whiteboards

Chapter 8: Multiparticle systems

Review single particle system: Projectile



$$\vec{F}_{net} = \langle 0, -mg, 0 \rangle$$

$$\Delta \vec{p} = \vec{F}_{net} \Delta t$$

$$\vec{p}_f = \vec{p}_i + \langle 0, -mg, 0 \rangle \Delta t$$

$$m\vec{v}_f = m\vec{v}_i + \langle 0, -mg, 0 \rangle \Delta t$$

$$v_{f,x} = v_{i,x} \qquad v_{f,z} = v_{i,z}$$

$$v_{f,y} = v_{i,y} - g\Delta t$$

$$\Delta \vec{r} = \vec{v}_{avg} \Delta t$$

$$y_f = y_i + \left(\frac{v_{f,y} + v_{i,y}}{2}\right) \Delta t$$

$$\boxed{y_f = y_i + v_{i,y} \Delta t - \frac{1}{2} g (\Delta t)^2}$$

Sample movies of fireworks, pencil, Earth/Moon

$$\vec{P}_{tot} = M_{tot}\vec{v}_{cm} \qquad M_{tot} = m_1 + m_2 + \dots$$

$$\vec{P}_{tot} = \sum_i \vec{p}_i$$

$$M_{tot}\vec{r}_{cm} = m_1\vec{r}_1 + m_2\vec{r}_2 + \dots$$

$m_1 = m_2$

$m_1 \gg m_2$

$$K_{tot} = \sum_i K_i$$

$$= K_{tran} + K_{rel}$$

↳ $= \frac{1}{2} M_{tot} V_{cm}^2$

Same as point particle system

Ponderable: Two particles

1) 2kg, velocity $\langle 3,5,0 \rangle$ m/s

2) 3kg, velocity $\langle -4,2,0 \rangle$ m/s

$\vec{V}_{cm}$?: $\vec{V}_{cm} = \frac{2\langle 3,5,0\rangle + 3\langle -4,2,0\rangle}{2+3}$ m/s $= \langle -1.2, 3.2, 0 \rangle$ m/s

K_{tot}?: $K_{tot} = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = 64$ J

K_{tran}?: $K_{tran} = \frac{1}{2} M_{tot} V_{cm}^2 = \frac{1}{2}(m_1 + m_2) V_{cm}^2 = 29.2$ J

K_{rel}?: $K_{rel} = K_{tot} - K_{tran} = 34.8$ J

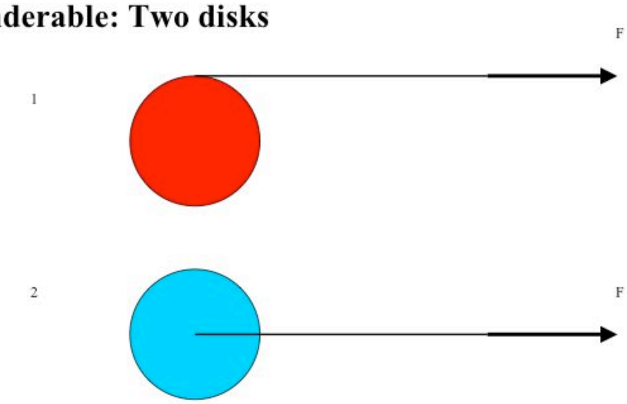
$\vec{V}_{1\,rel\,cm} = \vec{V}_1 - \vec{V}_{cm}$ ...

Momentum and Momentum Principle for multiparticle systems

$$\vec{P}_{tot} = M_{tot}\vec{V}_{cm}$$

$$\frac{d\vec{P}_{tot}}{dt} = \vec{F}_{net,surr}$$

Ponderable: Two disks



$$\vec{F}_{net} = \frac{\Delta \vec{p}_{sys}}{\Delta t}$$

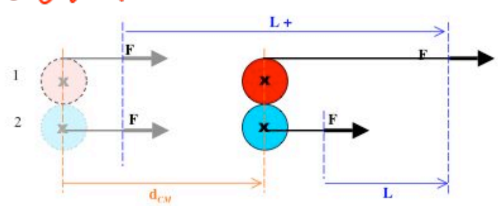
$$\Rightarrow \Delta \vec{p}_{sys} = \vec{F}_{net} \Delta t$$

String attached and wound around disk 1, attached to center of disk 2. Pull each with same force F for 3 seconds.

A) 1 will move farther than 2
B) 2 will move farther than 1
C) 1 and 2 will move the same

Even: Change in energy of point particle system

Odd: —— " —— real system



Point particle:

$$\Delta E = W + \cancel{Q} = W$$

$$\Delta K_{tran} = W = F d_{cm}$$

Real System: $\Delta E = W + \cancel{Q} = W$

$$\Delta E = \Delta K_{tran} + \Delta K_{rot} = F(d_{cm} + L)$$

$$\Rightarrow \Delta K_{rot} = FL$$

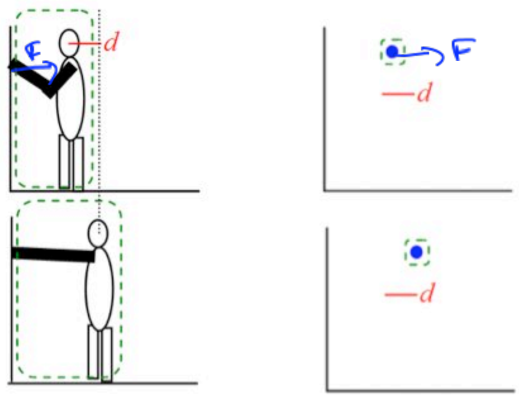
Skater starts at rest

Pushes with force F,

moving center of mass

distance d.

Ponderable: Skater



Even: Real System for $\Delta E = ?$

Odd: Point particle for $\Delta E = ?$

Even: $\Delta E = W + \cancel{Q} = 0$

$\Delta E = 0 = \Delta K_{trans} + \Delta E_{int}$

Odd: $\Delta E = W + \cancel{Q}$

$\Delta K_{trans} = Fd$

$\Delta E_{int} = -\Delta K_{trans} = -Fd$

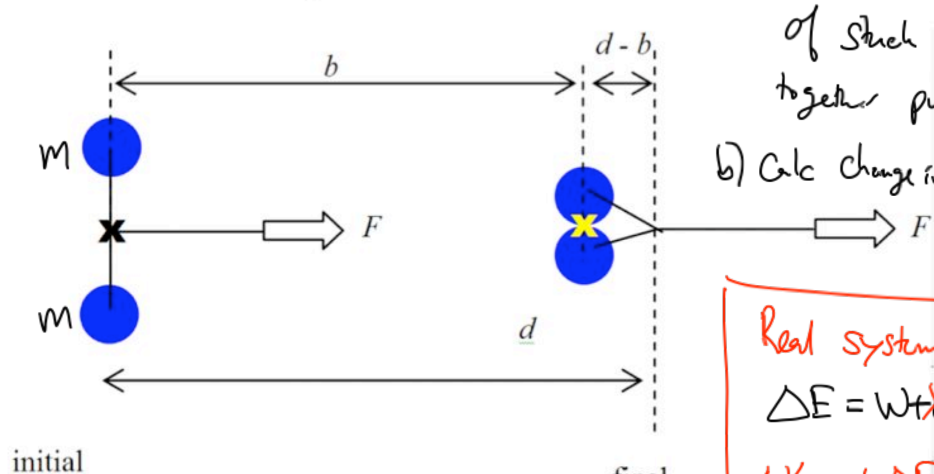
Starts at rest

Ponderable: Colliding disks

8.P.23

a) Final speed of stuck together pucks?

b) Calc change in internal energy



Point Particle

$\Delta E = W + \cancel{Q}$

$\Delta K_{trans} = Fb$

$\frac{1}{2} M_{tot} v_{cm}^2 = \frac{1}{2}(2m) v_{cm}^2 = Fb \Rightarrow v_{cm} = \sqrt{\frac{Fb}{m}}$

Real system

$\Delta E = W + \cancel{Q}$

$\Delta K_{trans} + \Delta E_{int} = Fd$

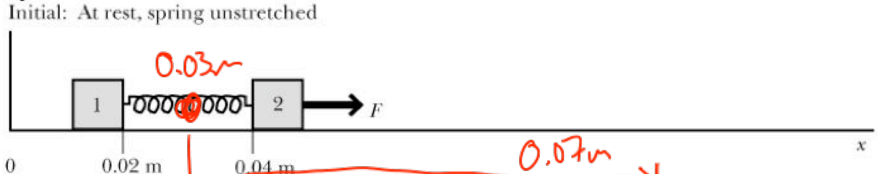
$\Delta E_{int} = Fd - \Delta K_{trans}$

$= Fd - Fb$

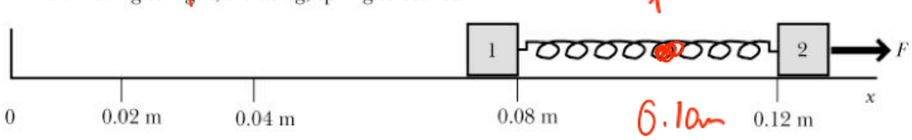
$\Delta E_{int} = F(d-b)$

Q1 Through what distance did the force act on the Point Particle system?

Initial: At rest, spring unstretched

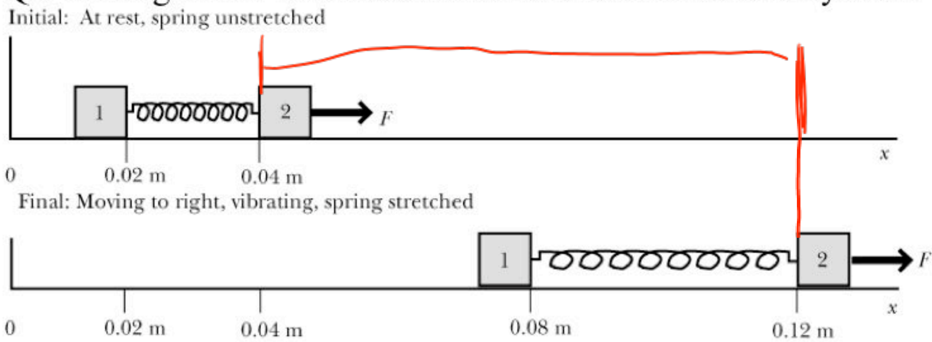


Final: Moving to right, vibrating, spring stretched



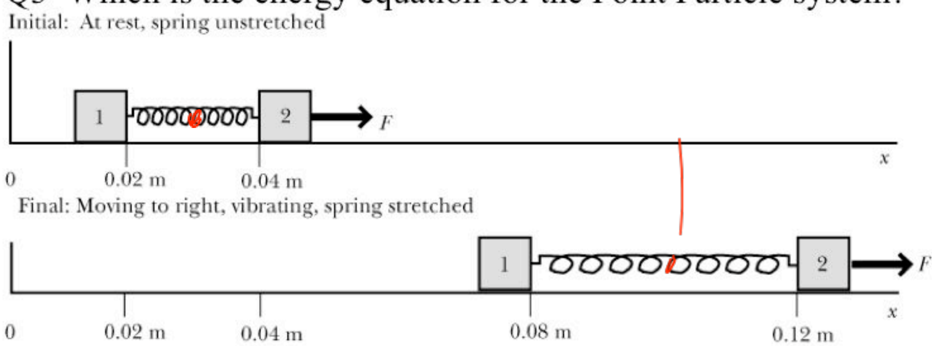
A) 0.03 m
B) 0.04 m
C) 0.07 m
D) 0.08 m
E) 0.10 m

Q2 Through what distance did the force act on the Real system?



A) 0.03 m
B) 0.04 m
C) 0.07 m
D) 0.08 m
E) 0.10 m

Q3 Which is the energy equation for the Point Particle system?



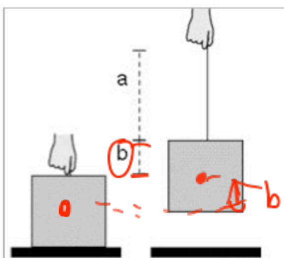
A) ΔK_{trans} = F*(0.07 m)

B) ΔK_{trans} = F*(0.08 m)

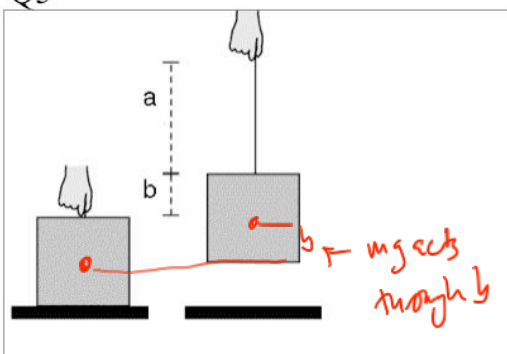
C) $\Delta K_{\mathbf{trans}} + \Delta K_{\mathbf{vib}} + \Delta U_{\mathbf{spring}}$ = F*(0.07 m)

D) $\Delta K_{\mathbf{trans}} + \Delta K_{\mathbf{vib}} + \Delta U_{\mathbf{spring}}$ = F*(0.08 m)

Q4

 You pull up with constant force *F*	For the Point Particle system, what was the total external work? A) $F*b + (-mg)*b$ B) $F*a + (-mg)*b$ C) $F*(a+b) + (-mg)*(b)$ D) $F*(a+b) + (-mg)*(a+b)$

Q5



You pull up with constant force F

For the Real system, what was the total external work?

A) $F*b + (-mg)*b$
B) $F*a + (-mg)*b$
C) $F*(a+b) + (-mg)*(b)$
D) $F*(a+b) + (-mg)*(a+b)$

Q6: A skater pushes straight away from a wall. She pushes on the wall with a force whose magnitude is F, so the wall pushes on her with a force F (in the direction of her motion). As she moves away from the wall, her center of mass moves a distance d. What is the correct form of the energy principle for the **real system** consisting of the skater?

A) $\Delta K_{\text{trans}} + \Delta E_{\text{internal}} = Fd$
B) $\Delta K_{\text{trans}} + \Delta E_{\text{internal}} = -Fd$
C) $\Delta K_{\text{trans}} + \Delta E_{\text{internal}} = 0$
D) $\Delta K_{\text{trans}} = Fd$
E) $\Delta K_{\text{trans}} = -Fd$

Wall does not move

Q7: A skater pushes straight away from a wall. She pushes on the wall with a force whose magnitude is F, so the wall pushes on her with a force F (in the direction of her motion). As she moves away from the wall, her center of mass moves a distance d. What is the correct form of the energy principle for the **point particle system** for the skater?

A) $\Delta K_{\text{trans}} + \Delta E_{\text{internal}} = Fd$
B) $\Delta K_{\text{trans}} + \Delta E_{\text{internal}} = -Fd$
C) $\Delta K_{\text{trans}} + \Delta E_{\text{internal}} = 0$
D) $\Delta K_{\text{trans}} = Fd$
E) $\Delta K_{\text{trans}} = -Fd$