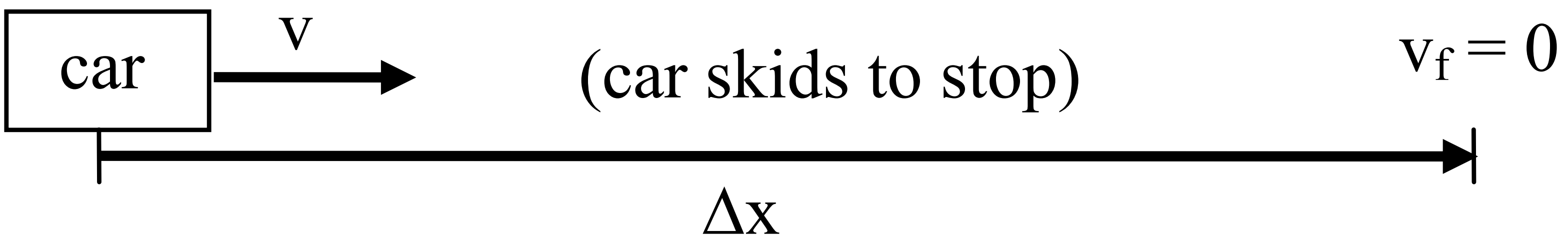
College Physics I: 1511 Mechanics & Thermodynamics

Professor Jasper Halekas
Van Allen Lecture Room 1
MWF 8:30-9:20 Lecture

Work-Energy Theorem(s)

- $W = \Delta KE$
- $W_{NC} = \Delta E$

Work-Energy Theorem Example



What is the work done by friction in stopping the car???

Work-Energy Theorem Example

- One Way:

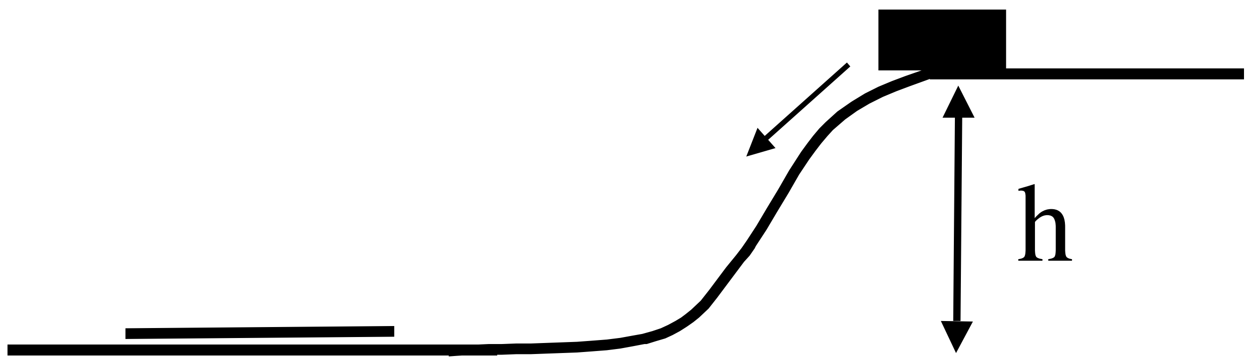
$$|W_{fric}| = F_{fric} \cdot |\Delta x| = \mu_K N \cdot |\Delta x|$$

- Another Way (much better if Δx is unknown!):

$$|W_{fric}| = |W_{net}| = |\Delta KE| = (1/2)\, m\, v^2$$

Concept Check

A mass slides down a frictionless ramp of height h and hits a carpet with kinetic friction coefficient $\mu_K = 0.5$
Its initial speed is zero.
How far does the mass slide along the carpet?



A: h **B**: Less than h **C:** More than h
D. Not enough information to decide.

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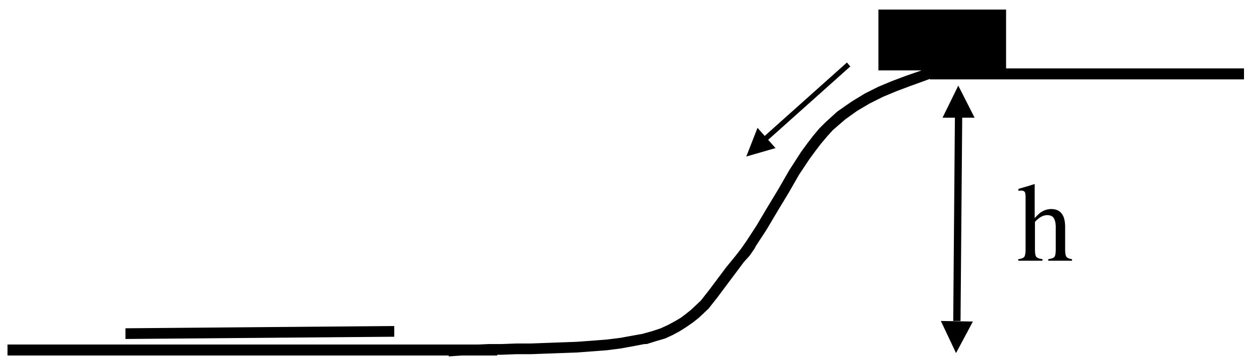

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Sliding Mass

E_0 at top $= PE_0 = mgh$

E_1 at bottom $= KE_{max}$

$E_1 = E_0$

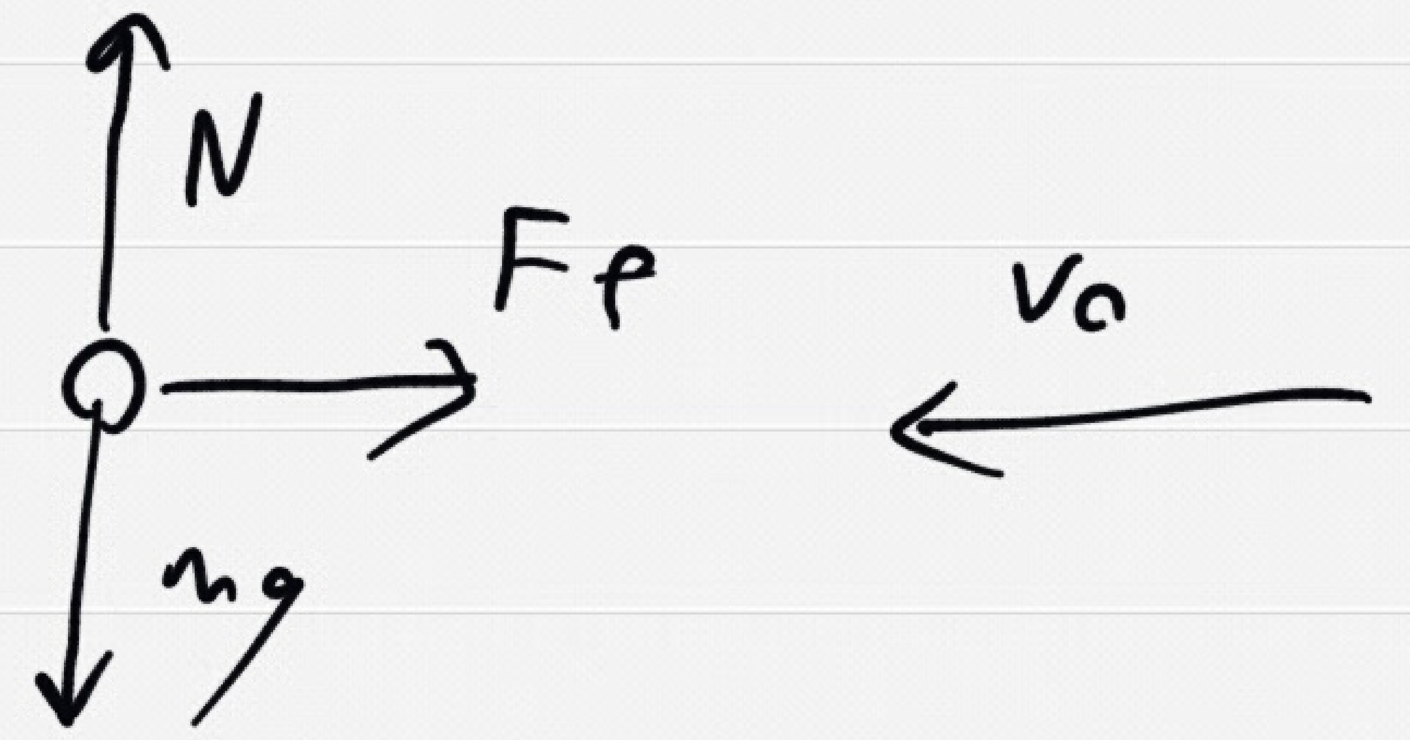
On carpet

$W_{NC} = \Delta E$

or $W_{net} = \Delta KE$

$F_f \cdot \Delta x = KE_{max} = mgh$

$F_f = \mu N = \mu mg$

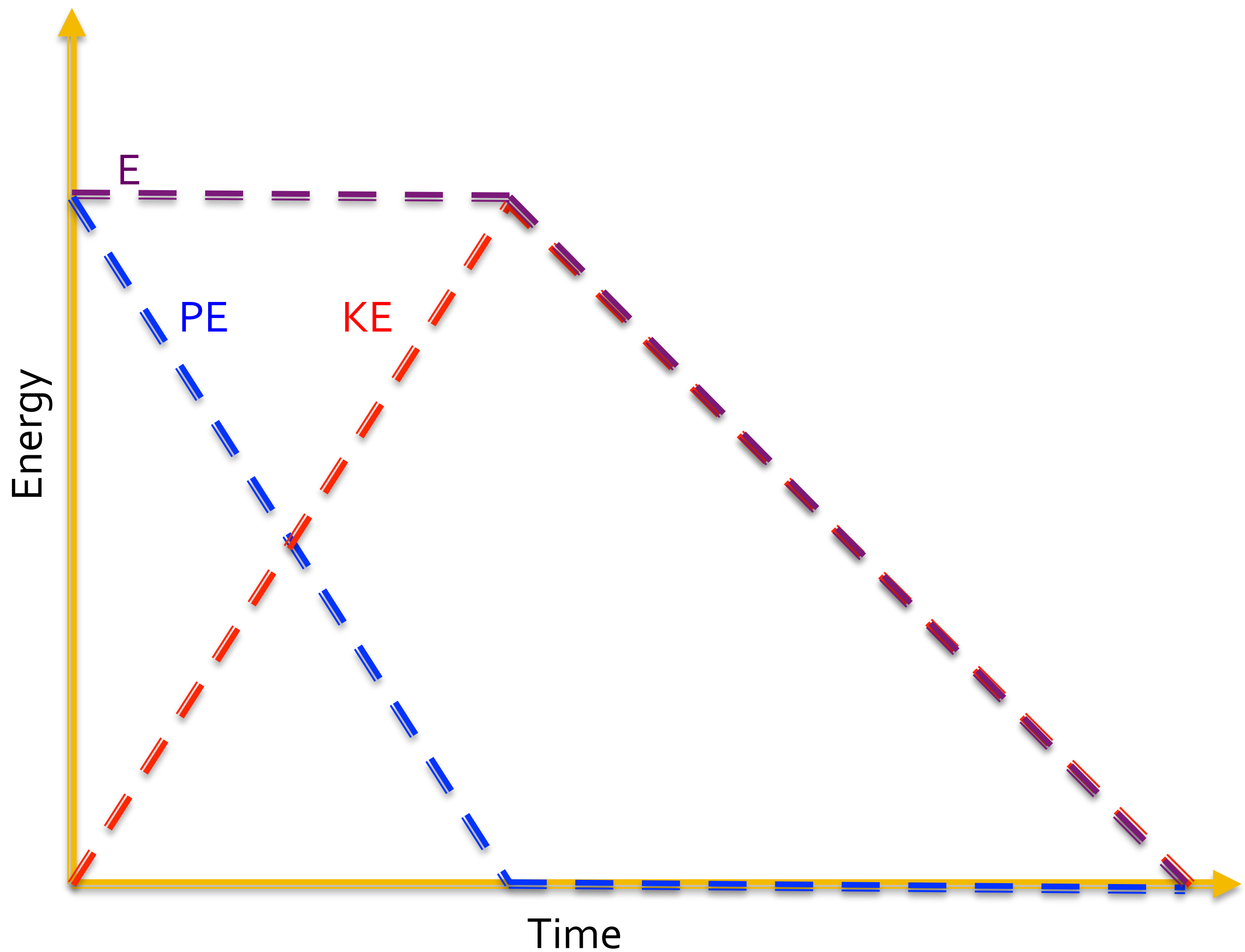


$\mu mg \Delta x = mgh$

$\mu \Delta x = h$

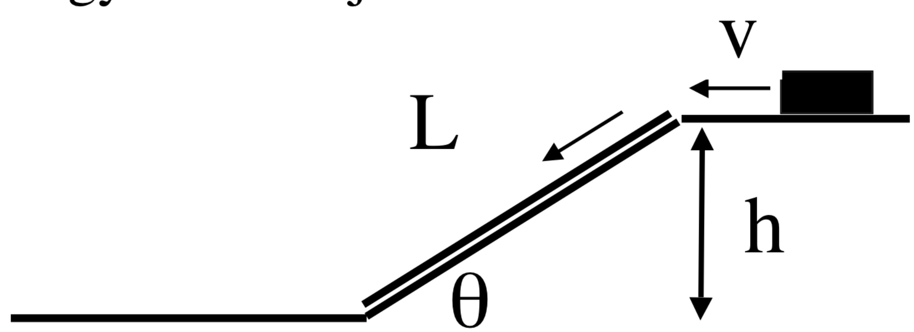
$\Delta x = h/\mu = \boxed{2h}$

Energy Graph



Concept Check

A mass slides down a ramp (height h, length L)
Its initial speed is v.
There is friction along the ramp (μ_K)
When it reaches the bottom, what is the final kinetic energy of the object?



A: 1/2 mv^2
B: 1/2 mv^2 + mgh
C: 1/2 mv^2 + mgh - μ_K mgL
D: 1/2 mv^2 + mgh - μ_K mg L cosθ
E: Not enough information to decide.

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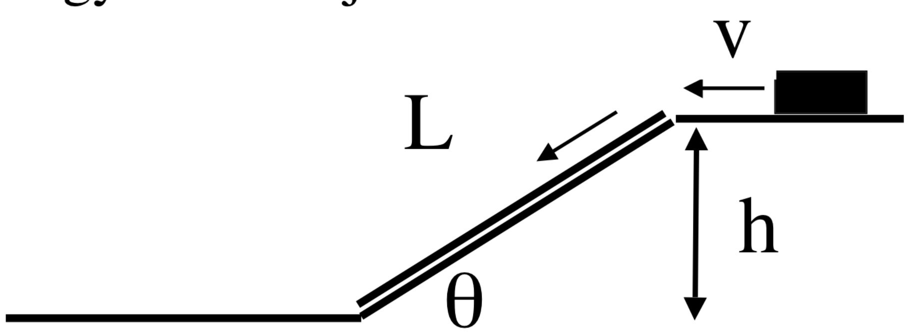

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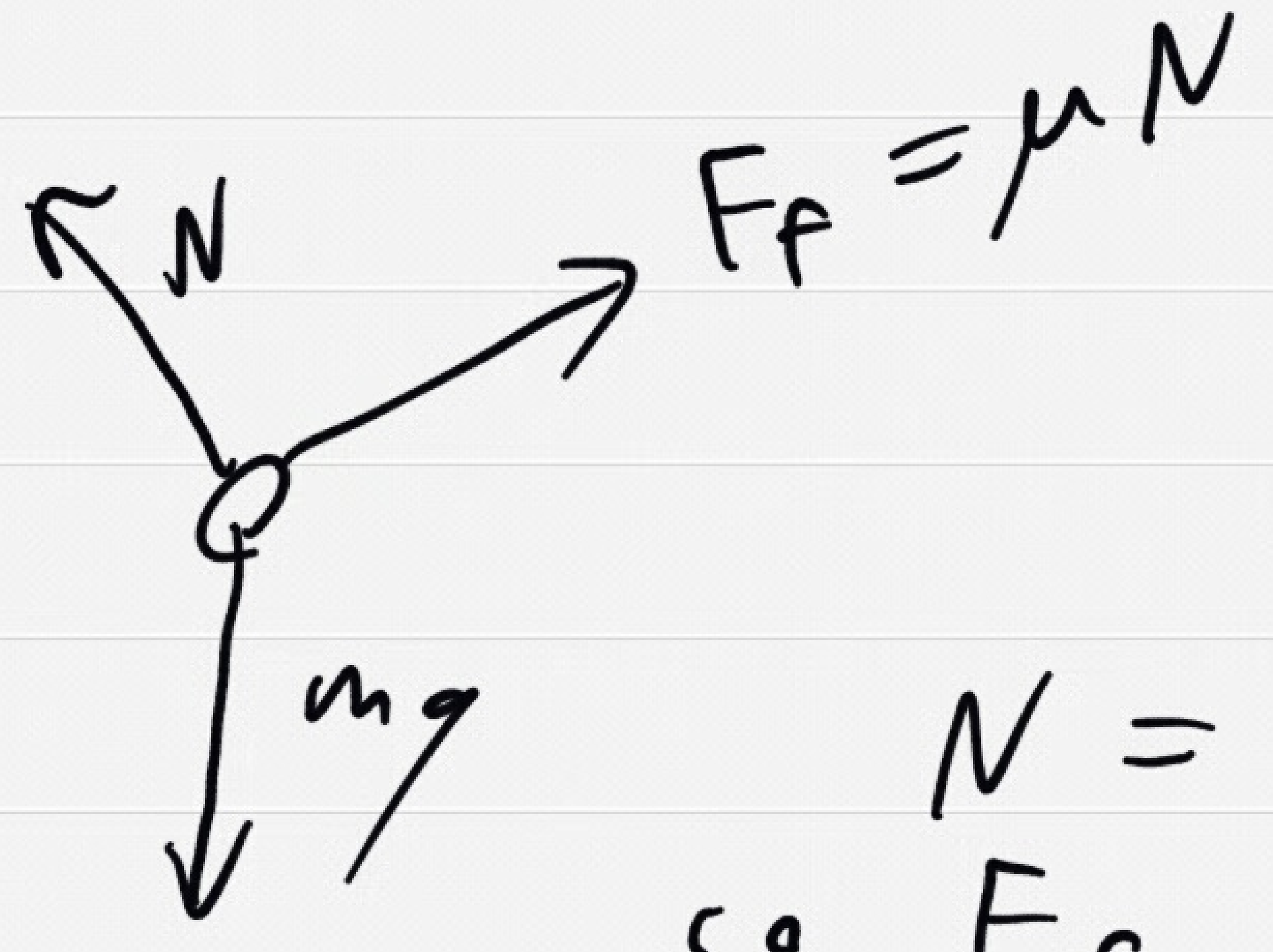
Sliding Mass 2



$N = mg\cos\theta$

so $F_f = \mu mg\cos\theta$

$E_0 = mgh + \frac{1}{2}mv^2$

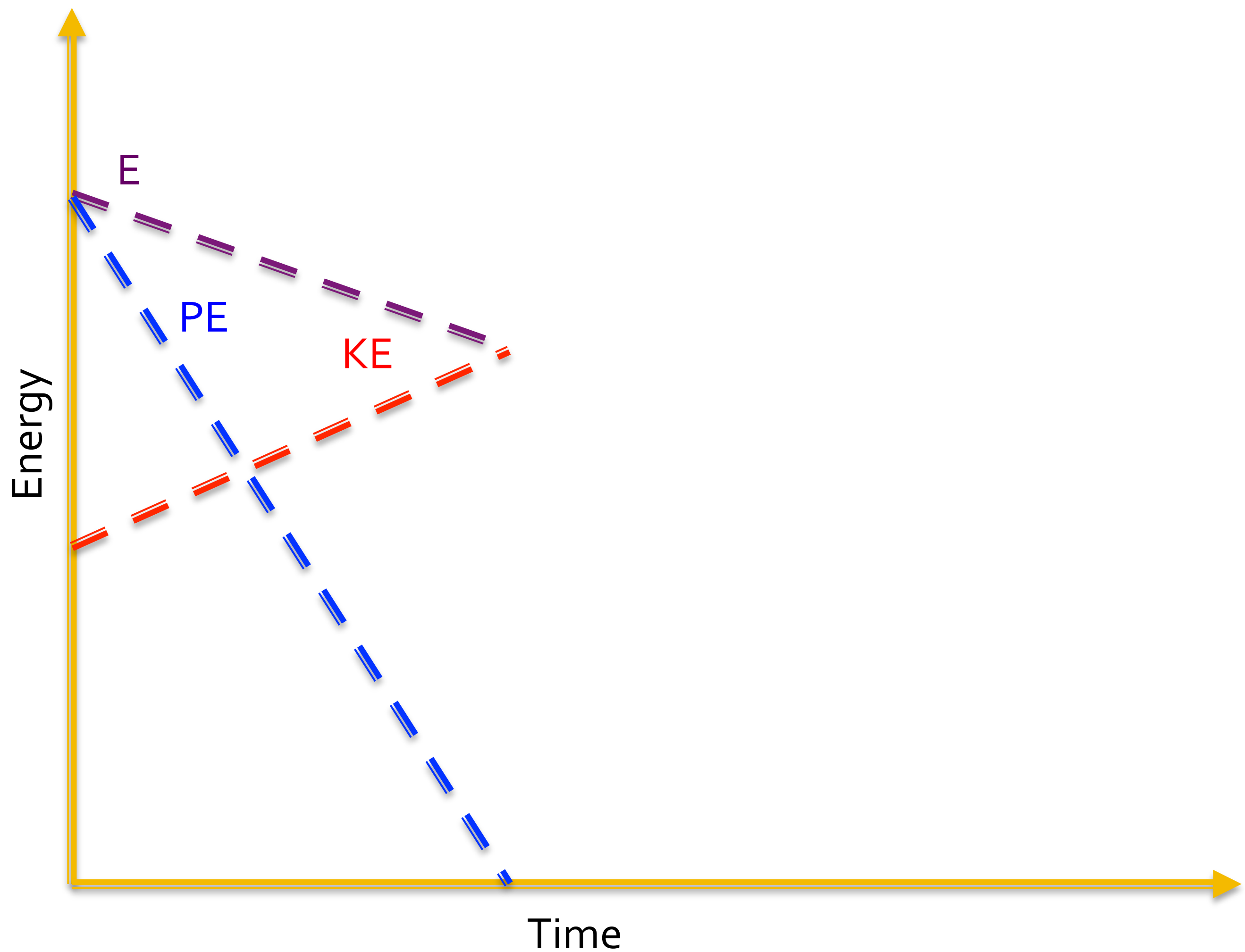
$E_1 = E_0 + W_{NC}$

$= E_0 - F_f \cdot L$

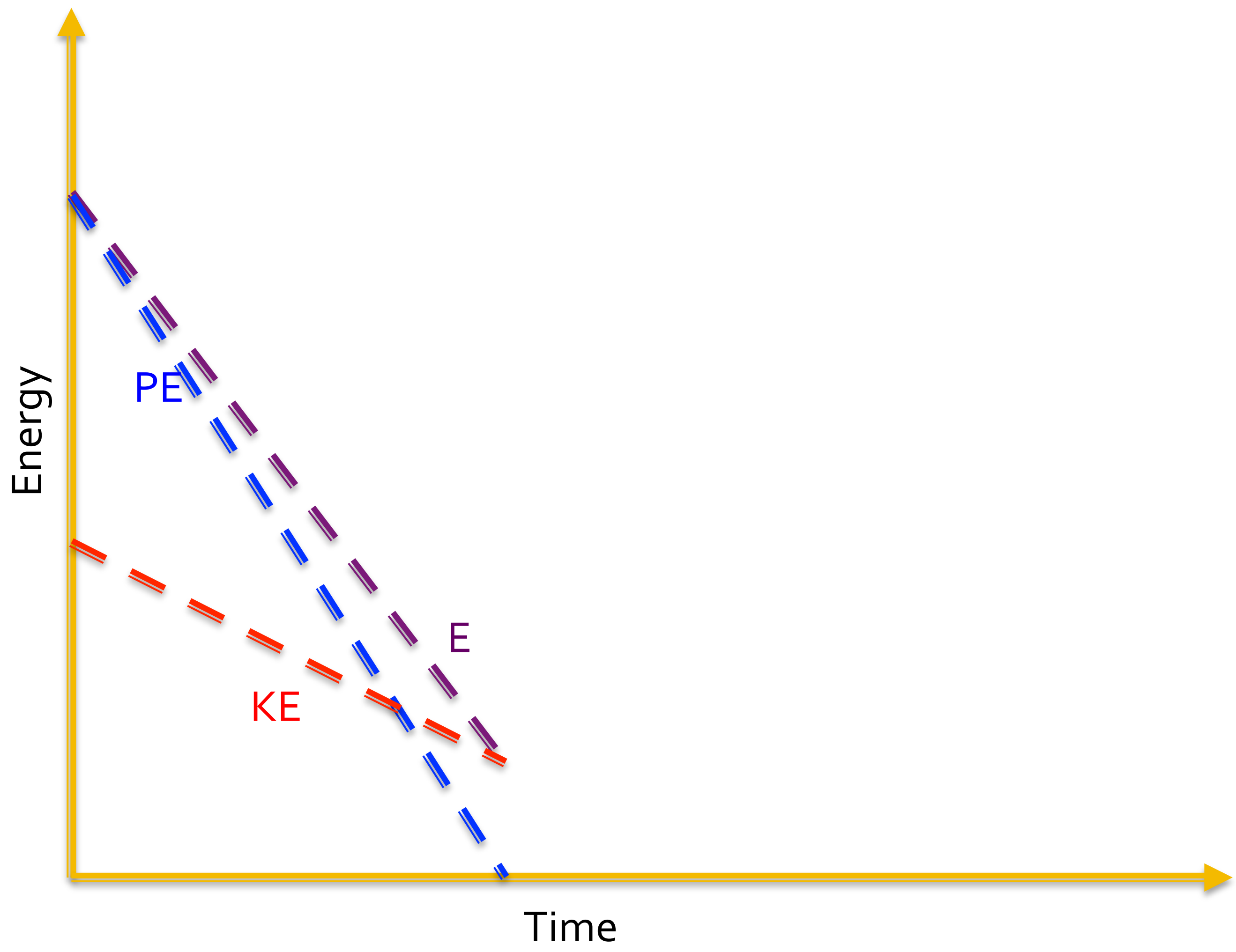
$= E_0 - \mu mg\cos\theta\, L$

$= mgh + \frac{1}{2}mv^2 - \mu mg\cos\theta L$

Energy Graph: Low Friction



Energy Graph: High Friction



Projectile Motion Reanalyzed: 1-d

- Say you want to find the maximum height a projectile reaches

- Old way: Solve $v_y = v_{yo} - gt = 0$ and plug into $y = y_o + v_{yo}t - 1/2\ gt^2$ to find highest point

- New way:
  - Solve $1/2\ mv_{yo}^2 + mgy_o = mgy$

Concept Check

- Imagine a gun that fires projectiles with a constant kinetic energy. If you fire a dart with mass m, and then a dart with mass 2*m, how do their maximum heights compare?

A. Second dart goes twice as high
B. Second dart goes to the same height
C. Second dart goes half as high
D. Second dart hits me in the nose

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Dart Gun

$$E = KE + PE$$

$$KE_0 + mgy_0 = mgy_f$$

$$mg(y_f - y_0) = KE_0$$

$$mgh = KE_0$$

$$h = \frac{KE_0}{mg}$$

Projectile Motion Reanalyzed: 2-d

- Say you want to find the total velocity at a given height…
- Old way: Solve equations for vertical displacement and velocity to find vertical velocity, then use Pythagorean theorem to find total velocity
- New way:
  - Solve $1/2\ mv^2 + mgy = 1/2\ mv_0^2 + mgy_0$

2-d projectile motion

$$\frac{1}{2} m v^2 + mgy = \frac{1}{2} m v_0^2 + mgy_0$$

How high does projectile go if $V_0 = [V_{x0}, V_{y0}]$?

$$\frac{1}{2} m v^2 + mgy = \frac{1}{2} m (V_{x0}^2 + V_{y0}^2) + mgy_0$$

$$V = [V_x, V_y]$$

$$= [V_{x0}, V_y] \text{ since } V_x \text{ const.}$$

$$\frac{1}{2} m (V_{x0}^2 + V_y^2) + mgy$$
$$= \frac{1}{2} m (V_{x0}^2 + V_{y0}^2) + mgy_0$$

$$\frac{1}{2} m V_y^2 + mgy = \frac{1}{2} m V_{y0}^2 + mgy_0$$

$V_y = 0$ @ top

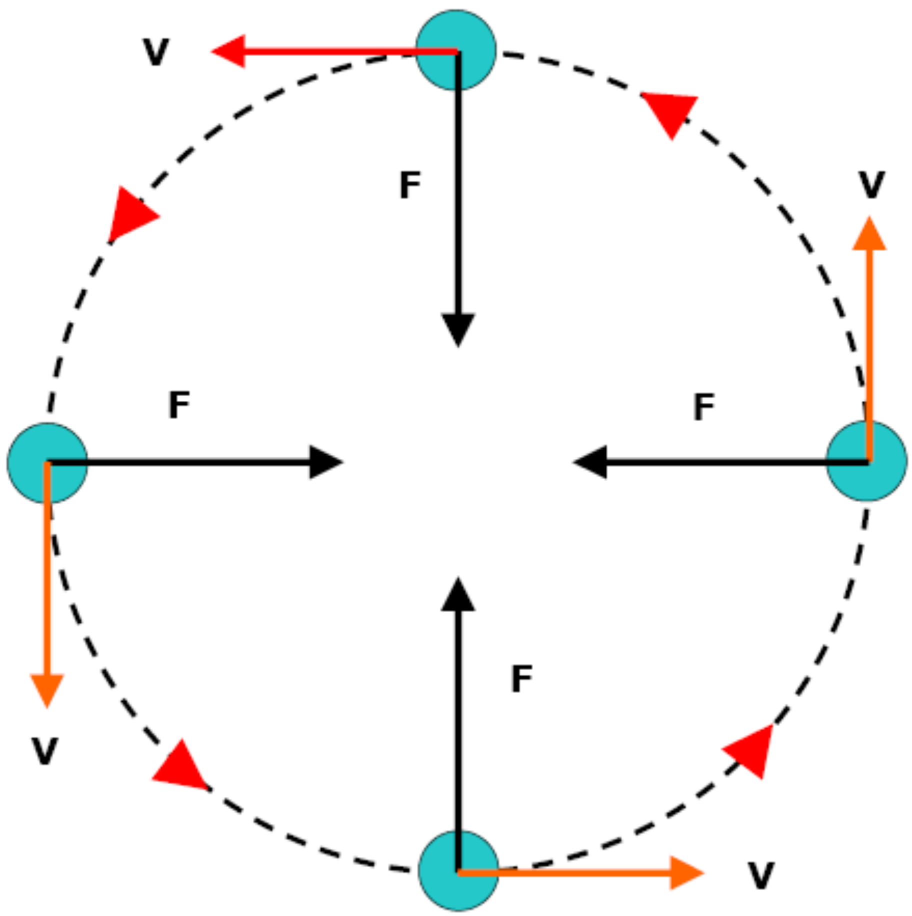
$$mgy = \frac{1}{2} m V_{y0}^2 + mgy_0$$
$$mg(y - y_0) = \frac{1}{2} m V_{y0}^2$$
$$mgh = \frac{1}{2} m V_{y0}^2$$

$$h = \frac{V_{y0}^2}{2g}$$

Projectile Motion Caveats

- Can't use conservation of energy to solve every aspect of projectile motion
- Conservation of energy tells you nothing (at least not directly) about the exact path the object follows
- Conservation of energy tells you nothing about how long it takes

Work of Uniform Circular Motion

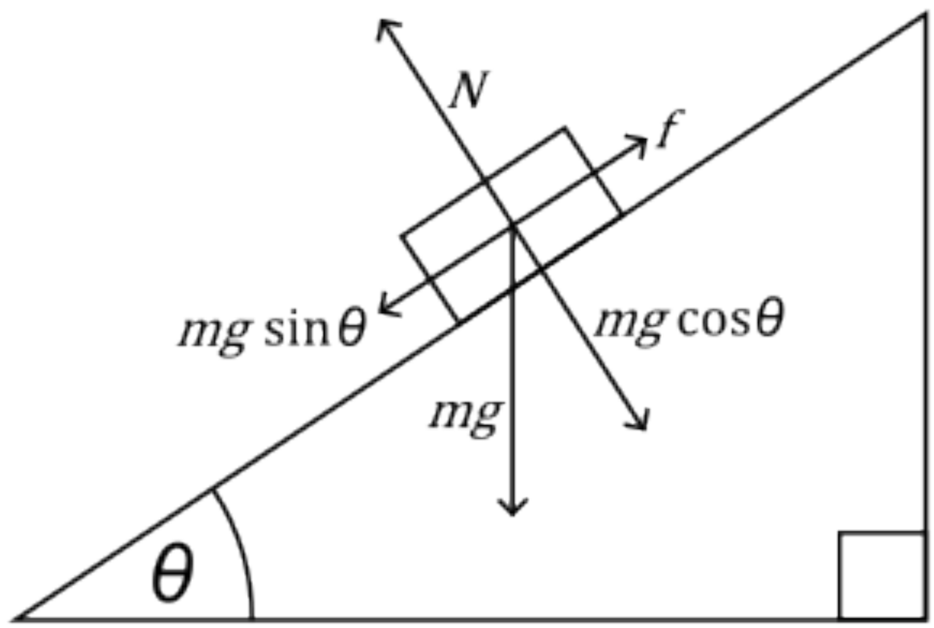


As long as v = constant, no work is done in circular motion

If v varies (non-uniform circular motion), then work is done

Can Normal Forces Ever Do Work?

- A. Yes
- B. No



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