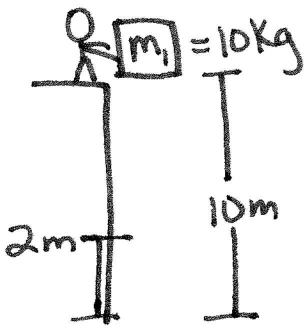
AP Physics Review

Energy Scenario #1: Free fall from 10m (just drop it)



What we Know:

$m_1 = 10Kg$

$h = 10m$

$V_0 = 0 m/s$

$g = 10 m/s^2$ (we're friends)

$U = mgh$ (max @ Top, min @ bottom)

$KE = \frac{1}{2}mv^2$ (min @ Top, max @ bottom)

What we can find out:

- Total work $= mgh = (10\,kg)(10\,m/s^2)(10m) = 1000J$
- $U_{2meters} = (10\,Kg)(10\,m/s^2)(2m) = 200J$

$KE_{2meters} = 1000J - 200J = 800J$

$V_{2meters} = 800J = \frac{1}{2}mV_{2m}^2 = \frac{1}{2}(10Kg)V_{2m}^2$

$V_{2m} = 12.65\,m/s$

- $V_{bottom} = \sqrt{2gh + V_0^2}$ ← since it was dropped, This is zero

You could also find $V_{2meters}$ by: $V_{2m} = \sqrt{2g(10m - 2m) + V_0^2}$ ← zero

look ☺ → Do you now see how

$$V^2 = V_0^2 + 2gh$$

comes from $\frac{1}{2}\cancel{m}v^2 - \frac{1}{2}\cancel{m}V_0^2 = \cancel{m}gh - \cancel{m}gh_0$

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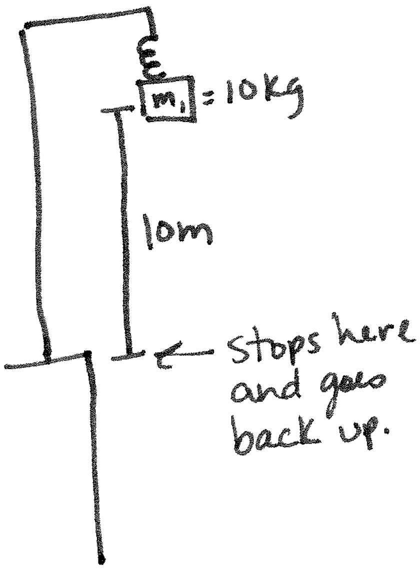
Energy Scenario #2 : 10 Kg mass on a spring



What We Know:

$V_0 = 0\,m/s$

$h = 10\,m$ (That's how far it will strech The Spring before it comes to a stop)

$F_0 = m_1 g$

$F_{bottom} = m_1 g - K\underset{\text{or "h"}}{X} = 0\,N$ (spring works against gravity)

$$\overline{F} = \frac{F_0 + F_{bottom}}{2} = \frac{F_0 + 0}{2} = \frac{F_0}{2}$$

$$Work = U = \frac{1}{2} F_0 X = \frac{1}{2} m_1 g h$$

$F_{spring} = KX$ So.... $Work = \frac{1}{2}(KX)X = \frac{1}{2}KX^2$

$$\boxed{W = U = \frac{1}{2} F_0 X = \frac{1}{2} KX^2}$$

units: Joules

What we can find out:

- V_{max} is @ middle of flight
- V_{min} is @ Top + bottom
- You can determine Spring constant (K)

$$F_{Spring} = F_{gravity}$$

$$KX = m_1 g$$

If you let it go and say it comes to rest some 3m below its starting point, Then $X = 3m$

$$K(3m) = (10\,Kg)(10\,m/s^2)$$

$$K = 33.3\ N/m$$

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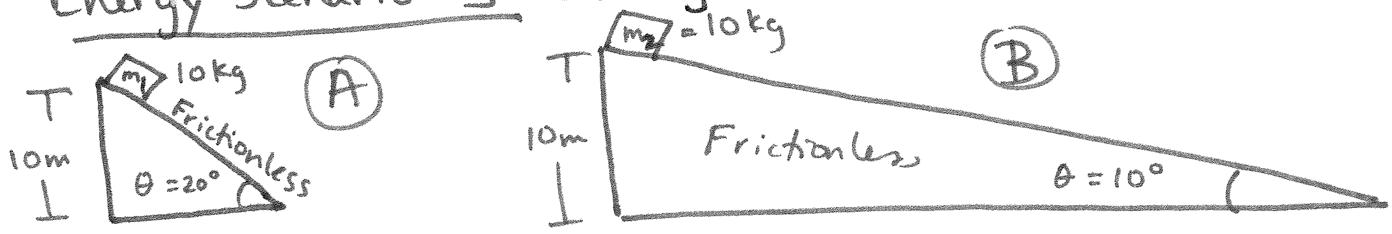
Energy Scenario # 3 Sliding down a frictionless Ramp



What we Know:

- $m_1 = m_2 = 10\,kg$
- both will go down a total of 10m $\left(\therefore U_{m_1} = U_{m_2} = mgh = 1000J \right)$ → (m = 10kg, g = 10 m/s², h = 10m)
  So both have same potential Energy!
- Both will have same KE @ bottom (1000J) and Therefore both will have same Velocity @ bottom (it just Takes m_2 longer to speed up to That Velocity)

Find V_{final} (Wow, They both work!)

- $KE = 1000J = \frac{1}{2}mv^2 = \frac{1}{2}(10kg)\,v^2$
  $V = 14.14\,m/s$
- OR $V^2 = V_0^2 + 2gh = 0^2 + 2(-10\,m/s^2)(10m)$
  $V = 14.14\,m/s$

Why do both equations work?: $V^2 = V_0^2 + 2gh$ is derived from The energy expression $KE_{max} = U_{max}$

Find Work:

$Work = F_{in\,x\,direction} \cdot Distance_{in\,x\,direction}$ = Joules = Energy

- Length of ramp (Distance in X direction) $= \frac{10m}{\sin\theta}$ So ramp (A) = 29.2m (B) = 57.5m
- $F_{in\,x\,direction} = mg\sin\theta$ (A) = 34.2N (B) = 17.36N

Work (A) = (34.2N)(29.2m) = 998.64J ≅ 1000J

Work (B) = (17.36N)(57.5m) = 998.2J ≅ 1000J

Wow! $Work = U = mgh = F_x \cdot d_x$

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Energy Scenario #3 Continued:

Find how long it takes for blocks to reach The bottom:

- Call The ramp X direction
- Use $X = V_0 t + \frac{1}{2} a t^2$ where $V_0 = 0\,m/s$ and $x = 29.2m$ (A) and $57.5m$ (B)

- $F_{(A)} = mg \sin\theta = m_{net}\, a_{net}$

$$\frac{\cancel{m} g \sin\theta}{\cancel{m}} = a_{net} = g \sin\theta = 10\,m/s^2 (\sin 20°) = 3.42\,m/s^2$$

$$a_{net\,(A)} = 3.42\,m/s^2$$

- a_{net} (B) $= g \sin\theta = 10\,m/s^2 (\sin 10) = 1.74\,m/s^2$

(Think about it.... as θ approaches $90°$, $\sin\theta = 1$ so a_{net} approaches g! Wow!)

- $X_{(A)} = 29.2m = 0 + \frac{1}{2}(3.42\,m/s^2)\, t^2$

$$t_{(A)} = 4.13\,sec$$

- $X_{(B)} = 57.5\,m = 0 + \frac{1}{2}(1.74\,m/s^2)\, t^2$

$$t_{(B)} = 8.13\,sec$$

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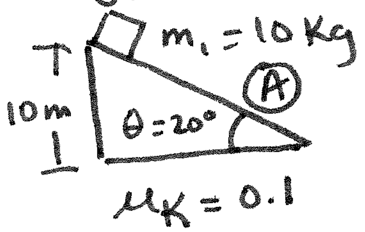
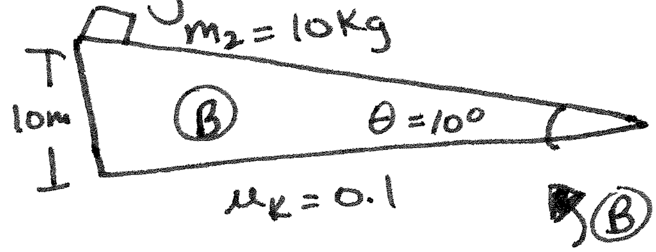
Energy Scenario # 4: Sliding down a ramp w/ Friction





(A) (B)

What We Know:

(A)	(B)
$N_1 = m_1 g \cos\theta = 93.9\,N$	$N_2 = m_2 g \cos\theta = 98.5\,N$
$F_{K_1} = (m_1 g \cos\theta)\mu_K = 9.39\,N$	$F_{K_2} = N\mu_K = 9.85\,N$
length of ramp $= \frac{10m}{\sin\theta} = 29.2m$	Length $= \frac{10m}{\sin\theta} = 57.5m$
$F_{x\,direction} = m_1 g \sin\theta = 34.2\,N$	$F_{x\,direct} = m_2 g \sin\theta = 17.36\,N$

What We can Find out:

$\text{Work} = U = mgh = 10\,Kg \cdot 10\,\frac{m}{s^2} \cdot 10m = 1000J$

Everything would be fine if no friction. Work would equal potential energy and would be the same for (A) + (B)

But since There is friction, and since length of ramp (B) > length of ramp (A), friction works against the sliding block and reduces the amount of Kinetic energy available @ the bottom of the hill (and, w/ less Kinetic energy, we have less final Velocity too!)

m_1 will have a faster final Velocity because friction won't have as long of an effect on it as (B).

$\text{Work} = F_{net} \cdot \text{distance} = (F_x - F_K)(\text{length of ramp})$

(A) $\text{Work} = (34.2N - 9.39N)(29.2m) = 724J$ ← Work done by gravity minus friction

(B) $\text{Work} = (17.36N - 9.85N)(57.5m) = 432J$ ←

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Energy Scenario #4

To find work lost to friction:

U_{max} − Work$_{gravity - Friction}$

(A) 1000J − 724J = 275J ← Energy lost to friction

(B) 1000J − 432J = 568J ←

To find speed @ bottom of hill:

Use Work$_{gravity}$ − friction because That is The net force times distance

(A) $KE = 724J = \frac{1}{2}mv_1^2$

$V_1 = 12.0$ m/s

(B) $KE = 432J = \frac{1}{2}mv_2^2$

$V_2 = 9.30$ m/s

To find how long it takes to reach bottom:

$X = V_0 t + \frac{1}{2}at^2$ ← where x = length of ramp; $V_0 = 0$ m/s

(A) $a_1 = \frac{F_x - F_K}{m_1} = \frac{34.2N - 9.39N}{10kg} = 2.49\,m/s^2$

(B) $a_2 = 0.751\,m/s^2$

(A) $X = 29.2m = 0 + \frac{1}{2}(2.49\,m/s^2)t^2$

$t_1 = 4.84$ sec

(B) $X = 57.5\,m = 0 + \frac{1}{2}(0.751\,m/s^2)t^2$

$t_2 = 12.37$ sec

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Energy Highlights:

$Work = \Delta U = \Delta KE =$ Joules!

But, if a non-conservative force such as friction acts on an object, $Work = \Delta U - (F_K \cdot d)$

Work equals the potential energy MINUS the force of friction multiplied over the distance the friction acts.

Look @ Scenario #4. Same μ_K for each, but in (A), the length of contact is shorter than in (B). Therefore, $Work_{net}$ is closer to U_{Total} for (A) Than it is for (B)

Mechanical Energy $= E = KE + U =$ Joules.

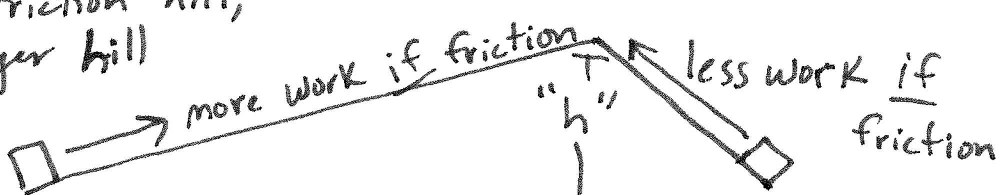
M.E. is conserved when no friction

$$E_0 = E$$

M.E. is not conserved when Friction (a non conservative force)

$$E_0 > E$$

- Conservative forces depend only on initial and final positions. Pathway doesnt matter. Hill length doesn't matter, only "h".
- non conservative forces are path dependent. If you move an object up a friction hill, The frictional work would be greater on a longer hill



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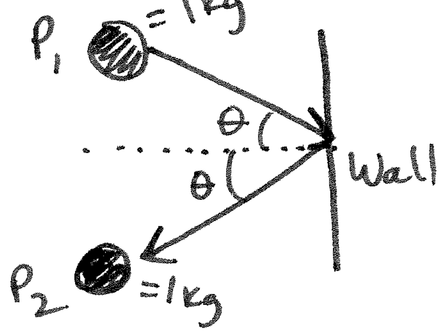
Momentum in a nutshell:

— $m_1 V_1 + m_2 V_2 = (m_1 + m_2) V_3$ (and Vice Versa)

— $P = m \cdot V$ (Scenario: Ball comes in @ θ, hits wall and ~~[illegible]~~ leaves @ θ.)



mass and Velocity are Unchanged by collision

-x direct.   +x direct.

x:

$\Delta P_{x\,direction} = P_{2x} - P_{1x} = -(P_2 \cos\theta) - P_1 \cos\theta$

notice P_1 is +x direction and P_2 is -x direction

$\therefore$ $P_2 \cos\theta + P_1 \cos\theta$ (if $P_1 = P_2$ Then $2P\cos\theta$)

y:

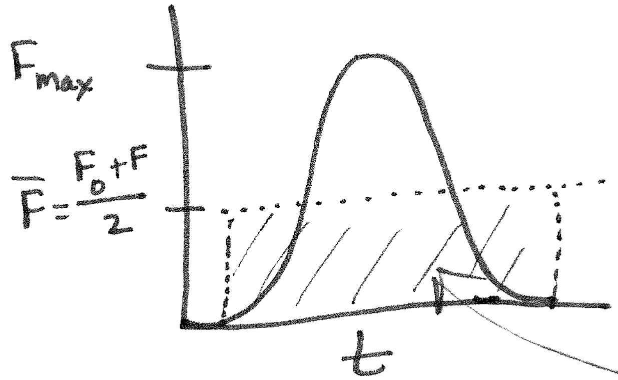
notice $P_{1y} = P_{2y}$ so Those cancel!

$\Delta P_{y\,direction} = P_2 \sin\theta - P_1 \sin\theta = 0$

Impulse:

$$F = \frac{\Delta P}{\Delta t}$$

$$\text{Impulse} = I = F\Delta t = \Delta P$$



Area in shaded box $\cong$ area under curve

Area Ft = impulse force

impulse force