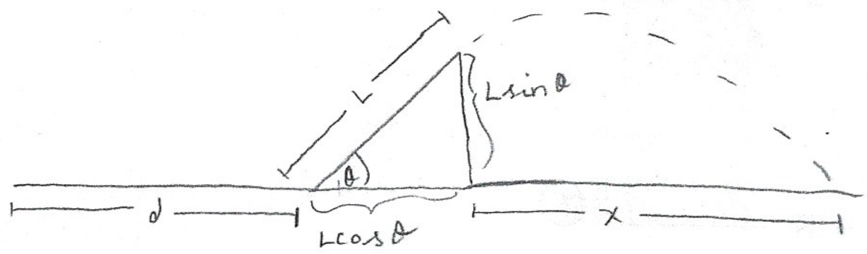
a. draw a cartoon



b. calculate how fast she travels when she leaves top of the ramp.

WANT TO USE WORK-ENERGY THEOREM, SINCE WE NEED TO CONSIDER THE THRUST FORCE & FRICTIONAL FORCE.

I'M GOING TO ASSUME THE ONLY SNOW WE ENCOUNTER IS ON THE RAMP ITSELF (SO WE CONSIDER FRICTIONAL FORCE FOR LENGTH OF RAMP L)

$\Delta KE = W_{THRUST}$ (I AM ONLY CONSIDERING FROM THE VERY START, TO THE BOTTOM OF THE RAMP)

$$\cancel{\frac{1}{2}m\vec{v}^2} - \frac{1}{2}m\vec{u}^2 = W_{THRUST}$$

(OMIT NEGATIVE, NOT NECESSARY) $\frac{1}{2}m\vec{u}^2 = F_T \cdot d \Rightarrow \vec{u} = \left[\frac{2F_T d}{m}\right]^{1/2}$ THIS IS HER SPEED WHEN SHE REACHES THE BOTTOM OF THE RAMP

NEXT WE CONSIDER HER ON THE RAMP.
WHILE ON THE RAMP, SHE ENCOUNTERS FRICTION, GRAVITY, & KE AT THE TOP OF THE RAMP.

$\Delta KE = W_{NET} \Rightarrow KE_f - KE_i = W_{friction} + W_{gravity}$

KE_f = KE at top of the ramp $- \frac{1}{2}mv^2$

KE_i = KE at bottom of the ramp $- \frac{1}{2}mu^2$

$W_{grav.} = F_g \cdot \Delta s$, WHERE $F_g = mg$ & $\Delta s = L\sin\theta$
FROM THE PICTURE, YOU CAN SEE $L\sin\theta$ IS THE VERTICAL DISTANCE & TRAVELED

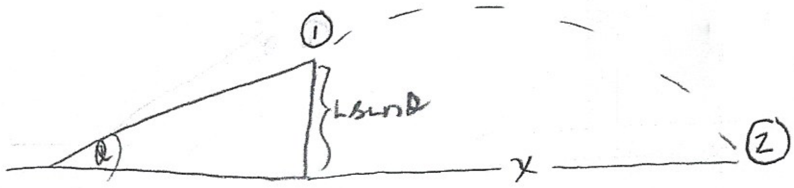
$W_{friction} = f_k \cdot \Delta s$ WHERE $f_k = \mu mg\cos\theta$ & $\Delta s = L$
(SINCE FRICTION IS ALL ON THE RAMP)

$$\frac{1}{2}\cancel{m}v^2 = \frac{1}{2}\cancel{m}u^2 + \cancel{m}gL\sin\theta + (\mu\cancel{m}g\cos\theta)L$$

$$v = \left[u^2 + 2gL\sin\theta + (2\mu g\cos\theta)L\right]^{1/2}$$

(WE CAN PLUG IN FOR u HERE, BUT AS YOU CAN SEE IM RUNNIN LOW ON ROOM!)

c. calculate how fast she is traveling when she lands back on the ground.



CONSIDER POINTS 1 & 2 TO BE OUR KE_i & KE_f RESPECTIVELY.

AGAIN, WE USE WORK-ENERGY.

$$\Delta KE = W$$

$$KE_f - KE_i = W$$

WHERE THE WORK IS ONLY THE WORK DUE TO GRAVITY. SHE IS OFF THE RAMP, SO NO FRICTION, & THERE ARE NO OTHER FORCES ACTING ON HER.

$$W = W_{gravity} = F_g \cdot \Delta s$$

AGAIN, Δs IS THE VERTICAL DISTANCE FROM 1 → 2.

FROM THE PICTURE, IT IS GIVEN BY $L\sin\theta$.

$$KE_i = \frac{1}{2} m \vec{u}^2$$

| I AM REUSING u HERE TO BE THE INITIAL VELOCITY, WHICH IS THE VELOCITY SHE LEAVES THE RAMP WITH. (IN THIS NEW PROBLEM, THAT HAS BECOME THE INITIAL VELOCITY)

$$KE_f = \frac{1}{2} m \vec{v}^2$$

(NOW THIS $\vec{v}$ IS WHAT WERE SOLVING FOR)

ALL TOGETHER:

$$KE_f = KE_i + W_{gravity}$$

$$\frac{1}{2} \cancel{m} \vec{v}^2 = \frac{1}{2} \cancel{m} \vec{u}^2 + \cancel{m} g L \sin\theta$$

$$v = \left[u^2 + 2gL\sin\theta\right]^{1/2}$$

SINCE THE ONLY FORCE ACTING IS GRAVITY & WE ONLY NEED TO CONSIDER WORK FROM GRAVITY, WE CAN USE CONS. OF ENERGY & USE PE INSTEAD OF WORK. GRAVITATIONAL PE = WORK FROM GRAVITY

$PE = mgh$ WHERE h IS THAT SAME VERTICAL DISTANCE $L\sin\theta$

SO: $PE = mgL\sin\theta$

2. can you energy methods to solve for horizontal distance?

IN THIS CASE NO.

LETS TRY ANYWAY, & SEE WHAT HAPPENS.

AGAIN, WERE LOOKING @ POINTS 1 & 2 & WITH PE & KE WE LOOK AT INITIAL & FINAL STATES.

WE SOLVED FOR KE_i & KE_f (KE_i HAS u, VELOCITY AT TOP OF THE RAMP, & KE_f WITH v, VELOCITY BEFORE HITTING THE GROUND.

NEXT WE CAN CONSIDER THE PE & WORK ENERGY (OUR GOAL IS TO LOOK AT ALL POSSIBLE PIECES OF USING ENERGY METHODS TO SEE IF WE CAN GET HORIZONTAL DISTANCE SOMEHOW)

IF WE USE CONS. OF ENERGY METHOD – LOOK AT PE

IF WE USE WORK-ENERGY – LOOK AT WORK

1 CONS. OF ENERGY

ONLY GRAVITATIONAL PE SINCE SHE IS UP ON A RAMP.

THE VERTICAL HEIGHT IS $L\sin\theta$

$PE_i = mgh = mgL\sin\theta$

$PE_f = 0$ (SHES ON THE GROUND)

$KE_i = \frac{1}{2}mu^2$, $KE_f = \frac{1}{2}mv^2$

$PE_i + KE_i = \cancel{PE_f}^{0} + KE_f$

$mgL\sin\theta + \frac{1}{2}mu^2 = \frac{1}{2}mv^2$

THE ONLY DISTANCE HERE IS THE VERTICAL

∴ CANNOT SOLVE FOR "x" WITH CONS. OF ENERGY)

2 WORK - ENERGY

$KE_i = KE_f + W$

AS BEFORE, THE ONLY FORCE IS GRAVITY SO WE WANT $W_{gravity}$ &, AGAIN, WANT THE VERTICAL DISTANCE SINCE GRAVITY ACTS VERTICALLY DOWN

$W_{grav.} = F_g \cdot \Delta s = mgL\sin\theta$

ALL TOGETHER:

$\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + mgL\sin\theta$

SAME AS BEFORE, NO WAY OF OBTAINING "x"

WE'VE SHOWN IT CAN'T BE DONE. BUT THERE'S MORE PHYSICS BEHIND THIS:

KE ALONE DOES NOT DEPEND ON DISTANCE, IT DEPENDS m & v, & WE ONLY CONSIDER INITIAL & FINAL STATES. LIKE BOTTOM OF RAMP TO THE TOP, OR THE TOP THEN ALL THE WAY TO THE GROUND.

PE (GRAVITATIONAL) DEPENDS ON VERTICAL DISTANCE.

WORK IS HOW WE CAN RELATE THE KE TO DISTANCE. & CAN RELATE $PE_{grav.}$ TO $W_{grav.}$

IF YOU LIFT A BOX STRAIGHT ... UP FROM THE GROUND, YOU ARE APPLYING A FORCE UPWARD TO OPPOSE GRAVITY PULLING DOWN. YOU'VE BASICALLY GIVEN THE BOX ENERGY IN ORDER TO LIFT IT. AT THE TOP, THAT ENERGY YOU GAVE THE BOX (THAT YOU CAN CALCULATE WITH $F \cdot \Delta s$) IS STORED AS PE (UNTIL IT FALLS & BECOMES KE). SO YOU CAN SEE, GRAVITATIONAL PE = WORK (GRAVITY) BUT THAT ONLY CONCERNS VERTICAL DISTANCES.

IN ORDER TO CHANGE KE, YOU NEED WORK. THINK, IF YOU APPLY SOME FORCE TO PUSH SOMETHING (IN SOME DIRECTION THAT IS THE SAME DIRECTION AS THE APPLIED FORCE) YOU ARE GIVING IT ENERGY TO SPEED UP OR SLOW DOWN.

$\Rightarrow \Delta KE = W_{net}$, APPLYING WORK GETS US FROM $KE_i \rightarrow KE_f$

YOU CHANGE THE VELOCITY OF THE BOX BY APPLYING WORK (TO IT, & THAT CHANGE IN VELOCITY ACCOUNTS FOR THE CHANGE IN KE.

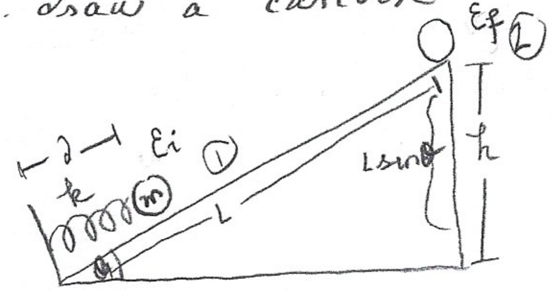
* I WANTED TO WRITE THIS OUT TO MAYBE HELP YOU GET A BETTER IDEA OF WORK, PE, & KE & THEIR RELATIONSHIPS *
(IF YOU KNEW ALL THIS ALREADY – FABULOUS!)

FINALLY, THE FINAL ANSWER

1. WE CAN ~~[illegible]~~ GET DISTANCE FROM WORK ($W = F \cdot \Delta s$)
2. (BESIDES CALCULATING IT DIRECTLY WITH $W = F \cdot \Delta s$) WE CAN RELATE WORK DONE TO ΔKE
3. THERE IS A CHANGE IN KE FROM ① → ② (STILL SAME SPOTS FROM PIC) SO THERE MUST HAVE BEEN WORK DONE, SO THERE MUST HAVE BEEN A FORCE TO CAUSE THAT CHANGE.
4. THE ONLY FORCE WAS GRAVITY, THAT ACTS VERTICALLY, SO THE WORK FROM GRAVITY WILL ONLY GIVE VERTICAL DISTANCES
5. WE COULD GET THE HORIZONTAL DISTANCE IF A FORCE WAS APPLIED HORIZONTALLY FOR DISTANCE "X" (BUT THIS IS NOT THE CASE

2. a pinball machine uses a spring loaded launcher to launch a ball up a ramp - it rolls up without slipping
want the speed of the ball at top of the ramp.

a. draw a cartoon



energy initial = energy final

$\Rightarrow E_i = E_f$

(picture shows initial & final locations)

b. write down an expression for conservation of energy

$PE_i + KE_i = PE_f + KE_f$

INITIALLY, THE BALL IS RESTING ON THE SPRING WAITING TO BE LAUNCHED $\Rightarrow$ NOT MOVING

$\Rightarrow KE_i = 0$

THAT LEAVES ONLY AN INITIAL PE, & IT COULD ONLY BE GRAVITATIONAL OR SPRING.

OF COURSE IT IS SPRING POTENTIAL, BUT I WROTE THIS OUT FOR FUTURE PROBLEMS, WHERE IT MIGHT BE USEFUL TO USE THIS PROCESS OF ELIMINATION METHOD FOR POTENTIAL, & ASK "IS IT MOVING" FOR KINETIC

$\Rightarrow PE_i = \frac{1}{2}kx^2$ (here $x = d$)

FINAL ENERGIES:

PE_f - GRAVITATIONAL OR SPRING?

THERES NO SPRING AT ② SO THATS OUT

BUT THINK THIS: THE BALL MOVED UP THE RAMP TO SOME HEIGHT h, THIS IS GRAVITATIONAL AS NOW THE BALL HAS SOME POTENTIAL TO FALL & HAVE THAT ENERGY BE CONVERTED TO KINETIC.

FINAL KINETIC:

NOW: IS IT ROTATIONAL OR TRANSLATIONAL?
THE BALL ROLLS UP THE RAMP, SO THERE MUST BE ROTATIONAL KE.
THERE IS ALSO TRANSLATIONAL KE, AS THE BALL HAS MOVED FROM ONE POINT TO ANOTHER ALL TOGETHER.

$$PE_i + \cancel{KE_i}^{\,0} = PE_f + KE_f$$

$$PE_{spring} = PE_{grav.} + KE_{rot.} + KE_{translational}$$

$$\Rightarrow \frac{1}{2}kd^2 = mgh + \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$$

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c. show that the speed at the top of the ramp is

INSERT SOME CRAZY EQUATION HERE

$$\frac{1}{2}kd^2 = mgh + \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$$

given: $I = \frac{2}{5}mr^2$

WE CAN FURTHER REDUCE OUR UNKNOWNS BY RELATING ω & v, WALTER (OH SO KINDLY) GIVES US $v = \omega r$
SINCE WE WANT THE TRANSLATIONAL VELOCITY, WE WANT TO REPLACE ω WITH v

$$v = \omega r \Rightarrow \omega = \frac{v}{r}$$

& LIKE BEFORE, THE h (in mgh) CAN BE DEFINED BY $L\sin\theta$ (REFER TO PICTURE IF LOST)

PLUGGING IN:

$$\frac{1}{2}kd^2 = mg(L\sin\theta) + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\left(\frac{v}{r}\right)^2 + \frac{1}{2}mv^2$$

$$\frac{1}{2}kd^2 - mg(L\sin\theta) = \frac{1}{5}m\cancel{r^2}\left(\frac{v^2}{\cancel{r^2}}\right) + \frac{1}{2}mv^2$$

$$\frac{1}{2}kd^2 - mg(L\sin\theta) = \frac{7}{10}mv^2$$

$$\Rightarrow v = \left[\frac{10}{7}m^{-1}\left(\frac{1}{2}kd^2 - mg(L\sin\theta)\right)\right]^{1/2}$$

crazy equation obtained

i am NOT simplifying

3. a ball of mass m is connected to one end of a rubber band & swung in a circle.
the band has spring constant k & unstretched length r_0.
if swung at angular velocity ω, what length will it stretch the band?

IMMEDIATELY WE CAN SEE THAT THERES A PE ASSOCIATED WITH THE STRETCHED RUBBER BAND.
∴ WE CAN START TO APPLY CONSERVATION OF ENERGY (INSTEAD OF WORK-ENERGY)

SO:

$$PE_i + KE_i = PE_f + KE_f$$

IT FOLLOWS THAT WE SHOULD CONSIDER KE.
IS IT MOVING?
YES, SO THERE IS CLEARLY KE, BUT IS IT TRANSLATIONAL OR ROTATIONAL?
ROTATIONAL, THE MASS IS ROTATING ABOUT SOME CENTER RATHER THAN IT MOVING FROM SOME INITIAL PLACE TO SOME FINAL PLACE.
LET r BE THE TOTAL LENGTH OF STRETCHED BAND
LET x BE THE DISTANCE THE BAND WAS STRETCHED BY
LET I BE THE MOMENT OF INERTIA
THE BALL OF MASS m CAN BE THOUGHT OF AS A POINT MASS & THE RUBBER BAND IS MASSLESS.
THIS WAY WE DEFINE I BY $I = mr^2$

ACTUAL SOLVING, NEXT PAGE

$$PE_{SPRING} = KE_{ROT.}$$

$$\frac{1}{2}kx^2 = \frac{1}{2}I\omega^2$$

$$\frac{1}{2}kx^2 = \frac{1}{2}mr^2\omega^2$$

plug in $\omega = \frac{v}{r}$

$$\frac{1}{2}kx^2 = \frac{1}{2}m\cancel{r^2}\left(\frac{v^2}{\cancel{r^2}}\right)$$

$$\cancel{\frac{1}{2}}kx^2 = \cancel{\frac{1}{2}}mv^2$$

$$\Rightarrow x = \left[\frac{mv^2}{k}\right]^{1/2}$$