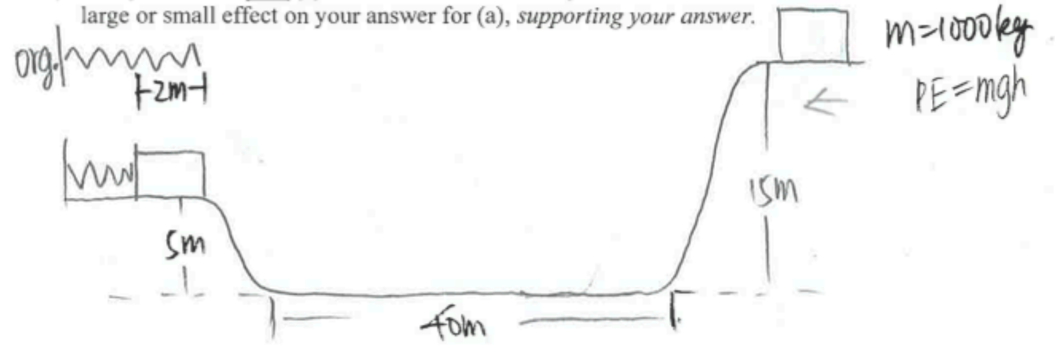
elevation, slide along 40 m on level ground and then rise up 5 m to the top of a hill on level ground, coming to a stop by compressing a spring by 2 meters.

a) Without finding the answer, explain completely how you would go about finding the spring constant from the information given, right up to and *including* setting up the formulas.

b) Without finding the answer, explain completely how to find the maximum acceleration as we compress the spring, right up to and *including* setting up the formula.

c) Let's say now that there is a coefficient of friction on the level part of the track of $\mu_d = 0.2$. Please describe how this would affect the way you solved (a) above for the spring constant.

d) *Save for the end **only** if you have extra time*. Can you tell me if the consideration of friction would have a large or small effect on your answer for (a), *supporting your answer.*



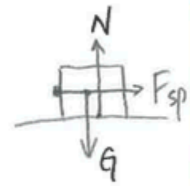
a) Energy lens, change form of energy.

$$PE_{15m} \Rightarrow KE_1 \rightarrow PE_{5m} + PE_{spring}$$

A $PE_{15m} = PE_{5m} + PE_{spring}$ $\quad mgh_{15m} = mgh_{5m} + \frac{1}{2}kx^2$

$$\boxed{k = \frac{mgh_{15m} - mgh_{5m}}{x^2}}$$

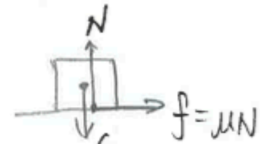
b) Dynamic lens, presence of force and acceleration.



$\sum \vec{F} = m\vec{a}$ $\quad F_{spring} = kx$

$F_{spring} = kx = ma$ $\quad \boxed{a = \frac{kx}{m}}$

c) Energy lens, change form of energy



Some of the potential energy change into friction as heat, so the final spring constant would be smaller $W_f = F \cdot x = \mu \cdot m \cdot g \cdot x = 0.2 \cdot 1000kg \cdot 10m/s^2 \cdot 40m = 80000J$

energy lens, energy is conserved (no outside force)

d) It would have a huge effect on my answer, $PE = mgh = 150000J$ and $W_f = 80000J$

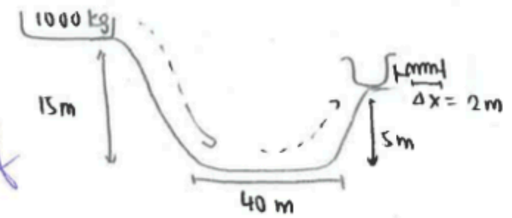
spring) right up to and *including* setting up the formula.

c) Let's say now that there is a coefficient of friction on the level part of the track of $\mu_d = 0.2$. Please describe how this would affect the way you solved (a) above for the spring constant.

d) *Save for the end **only** if you have extra time*. Can you tell me if the consideration of friction would have a large or small effect on your answer for (a), *supporting your answer.*

15000

A



a) We use an energy lens here because there are several energy transitions happening.

$PE_{gravity} \rightarrow KE \rightarrow PE_{gravity} + PE_{spring}$

To calculate spring constant (k),

we can use $PE_{before} = PE_{after}$.

$$mgh = mgh + \frac{1}{2}kx^2$$

15m 5m 2m

From here, we plug everything in and we'll be able to find k

b) Energy? lens since we know ~~that~~ $F = k\Delta x$, if we plug in k and the extension of spring, which is 2m, we will be able to find the force provided by the compression of spring. And with that force, we can plug it into $F = ma$

$\boxed{k\Delta x = ma}$

10000 × 2 = 20000, 20000 × 40 = 800000

c) If there was friction at the level, then the PE_0 will not be converted to KE entirely, instead, the energy transition will be,

$PE_{(15m)} \rightarrow KE + \text{Heat}$, $KE = PE_{(15m)} - \text{Heat}$

work done by friction

That means some of the energy are lost to friction, and that would reduce the KE of body, which reduce the total energy when the body gets up to the end of track. Therefore, spring would be compressed less as some energy is lost along the way, making k (spring constant) smaller.

d) If there was friction, the effect on k will be large. Without friction,

$PE_{initial\,(5m)} = mgh$

$= 1000\text{ kg}(10\text{ m/s}^2)(15\text{ m})$

this $\rightarrow = 1500000$ J would be converted completely to KE but with friction,

N, 1000 kg, Fg

$PE_{(15m)} \rightarrow KE + \text{Friction}$

$KE = 1500000\text{ J} - N\mu(d)$

$= 1500000\text{ J} - 10000\text{ N}(0.2)(40\text{ m})$

$= 1500000\text{ J} - 80000\text{ J} = 1420000\text{ J}$ ← A lot of energy is LOST by work done by friction

So spring will be compressed much less.

how this would affect the way you solved (a) above for the spring constant.

d) *Save for the end **only** if you have extra time*. Can you tell me if the consideration of friction would have a large or small effect on your answer for (a), *supporting your answer.*

a) using an energy lens I would look at the energy conversions.

$$\underbrace{PE_{Grav_1}}_{\text{part 1}} \Rightarrow \underbrace{Kenetic_1}_{\text{part 2}} \Rightarrow \underbrace{Kenetic_2 + PE_{Grav_2}}_{\text{part 3}} \Rightarrow \underbrace{PE_{spring} + PE_{Grav_2}}_{\text{part 4}}$$

40m

nice!

$$mgh \qquad \tfrac{1}{2}mv^2 \qquad \tfrac{1}{2}mv^2 \quad mgh \qquad \tfrac{1}{2}k(\Delta x)^2 \quad mgh$$

A

because energy is conserved in each of these conversions because no energy is lost to friction we can set any part equal to any other part.

$$PE_{Grav_1} = PE_{spring} + PE_{grav_2}$$

$$(1000kg)(10m/s^2)(15m) = \tfrac{1}{2}k(2m)^2 + (1000kg)(10m/s^2)(5m)$$

b) using a dynamics lens we can find the acceleration because force = ma and we know the force of the spring is $k(\Delta x)$.

$$F_{spring} = ma$$

$$k\Delta x = ma$$

$$k(2m) = (1000)(a)$$

units! -5 pts.

part d

c) If there was a coefficent of friction we would still use an energy lens but we would have to look at energy lost in heat due to friction. The force friction = Fnorm μ. We know the block isn't moving on the y axis so Fgrav = Fnorm or mg = Fnorm. $F_{frict} = mg\mu$. The work done by friction = the the ΔEnergy due to friction. $W = F * dx$, $W_{friction} = mg\mu(40m)$

table at right indicates the speed as a function of time.

a) Please make the graphs describing her motion. Make sure they have the right shape, and if you have time, please fill in the correct numbers.

1	8
2	6
3	4
4	2
5	0
6	0

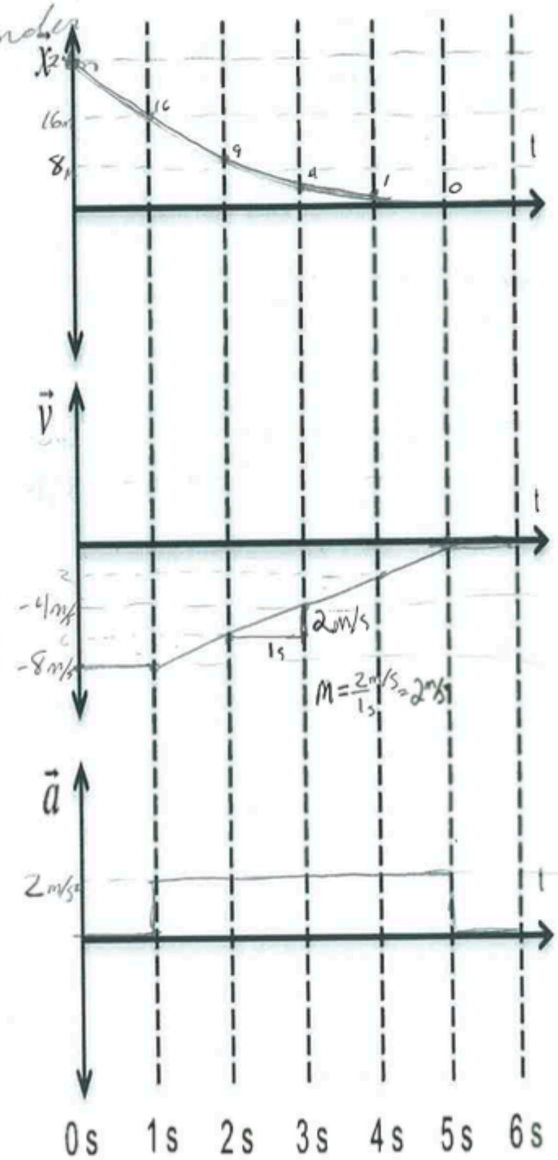
→ why?

using a kinematics lens we can look at the velocity graph in relation to time to Find both the acceleration and displacement. The displacment is the area under velocity and acceleration is the slope.

A

$\int v = 8 + 7 + 5 + 3 + 1 = 24m$

↑This is the initial height of the elevator



#1 d) Using an energy lens I can find the ΔE or Work done by friction. $W = F \cdot dx$, Force is the Force of friction or $F_{norm}\mu$. The block is not moving on the y axis so $F_{grav} = F_{norm}$ or $F_{norm} = mg$ so $F_{fric} = mg\mu$. W done by friction $= mg\mu\, dx$ or $(1000kg)(10m/s^2)(.2)(40m)$ we can compare this to the total Kenetic energy that the block has at this point to see how great the effect friction has on the block

#2 The mass of your friend is 50 kg and she is in a 450 kg elevator for a total mass of 500 kg. She is moving downward and her speed is decreasing as she stops on the ground floor. The table at right indicates the speed as a function of time.

a) Please make the graphs describing her motion. Make sure they have the right shape, and if you have time, please fill in the correct numbers.

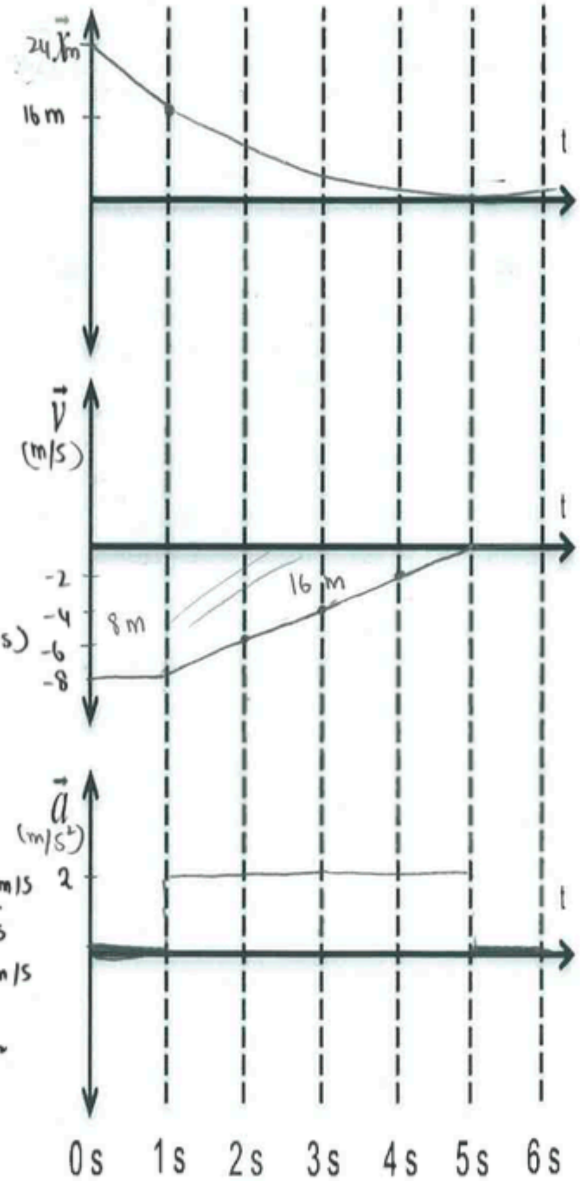
Time (s)	Speed (m/s)
0	8
1	8
2	6
3	4
4	2
5	0
6	0

a) Kinematics lens because we're talking about $\vec{x}$, $\vec{v}$ and a as a function of time.

A

$x = \int v\,dt$
$= 8\ m/s\,(1s)$
$\frac{1}{2}(8\ m/s)(4s)$
$= 24\ m$

$a = \frac{(-4-(-6))\ m/s}{3-2\ s}$
$= \frac{-4+6\ m/s}{1\ s}$
$= 2\ m/s^2$

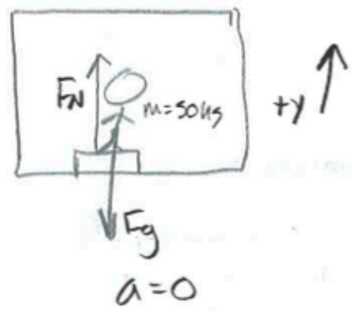


#3 Imagine your friend is 50 kg and is standing on a scale in the previous page.

a) What does the scale under her read at t = ½ s?

b) What does the scale under her read at t = 3 s?

$t = \frac{1}{2}s$



a) I will use a dynamics law because there are forces and accelerations

$$\sum \vec{F} = m\vec{a}$$

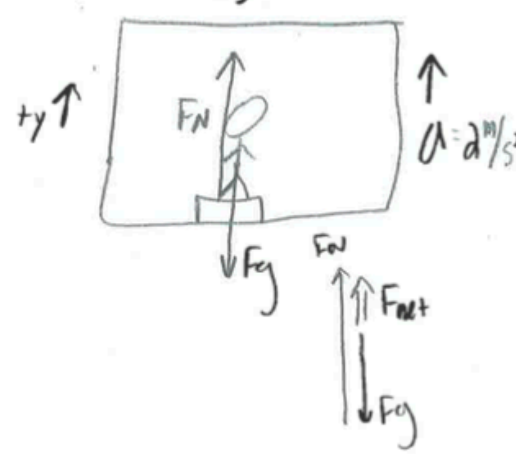
$$F_N + F_g = m\vec{a}$$

$$F_N = m\vec{a} + F_g \; ; \; \vec{a} = 0$$

$$F_N = F_g = mg = 50kg \cdot 10 m/s^2 = \boxed{500N}$$

b) I will use dynamics laws because there are forces and accelerations.

$t = 3s$



$$\sum \vec{F} = m\vec{a}$$

$$F_N + F_g = m\vec{a}$$

$$F_N = m\vec{a} + F_g = m\vec{a} + mg$$

$$F_N = (50kg)(2 m/s^2) + 500N$$

$$\boxed{F_N = 600N}$$

This makes sense b/c it should be greater than 500N since $\vec{a}$ is upward.

#3 Imagine your friend is 50 kg and is standing on a scale in the previous page.

a) What does the scale under her read at t = ½ s?

b) What does the scale under her read at t = 3 s?

a)

I use a kinematics & dynamics lens because we're talking about forces & acceleration (change of velocity in respect to time.)

↑ kinematics

At $t = \frac{1}{2}$, there was no change in velocity.

$a = 0$

$\sum \vec{F} = m\vec{a}$

$N - mg = 0$

$N = mg$

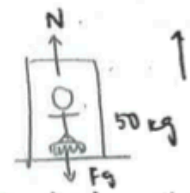
$= 50\,(kg)(10\,m/s^2)$

$= 500\,kg\,m/s^2$

$= 500\,N$

A

b)

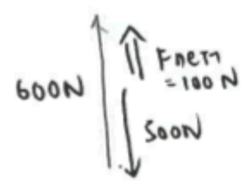


At t = 3, there is a change in velocity.

$$a = \frac{-4-(-6)\ m/s}{3-2\ \ s}$$

$$= \frac{-4+6\ m/s}{1\ \ s}$$

$$= 2\,m/s^2$$



$\sum \vec{F} = m\vec{a}$

$N - mg = 50\,kg\,(2\,m/s^2)$

$N - 500N = 100\,kg\,m/s^2$

$N = (100 + 500)\,kg\,m/s^2$

$= 600\,N$

#4 A 1.0 kg ball moving at 10 m/s *to the right,* has a totally *elastic* collision with *stationary* "Ball X" of unknown mass, and *turns around moving to the left* at 8 m/s. We want to find the mass of Ball X, and its final velocity.

a. Without doing any math, can you tell me if the mass of Ball "X" is more or less than 1 kg? That is: fill in the space with <, >, or = : m_X > 1 kg
please give a reason

← −8 m/s

?

KE gained by the 1kg is great bcuz ΔKE is 18 J. Since in a collision, momentum is conserved. (momentum of system is 10 kg m/s), this body that gains so much KE should the lighter body and the other body is heavier.

$\Delta KE = KE_f - KE_o$
$= \frac{1}{2}(1\,kg)(-8\,m/s)^2 - \frac{1}{2}(1kg)(10\,m/s)^2$
$= 18\,m/s$

b. What must be the momentum of Ball X after the collision? Explain completely

+ dir →

Use the lens of momentum because momentum is conserved when there's no outside force acting on it.

Before: (1kg) 10 m/s → (X) 0 m/s

After: ← (1kg) −8 m/s (X) - - →

Before		After
$m_1 v_1$	=	$m_1 v_1 + m_x v_x$
$1\,kg\,(10\,m/s)$	=	$1\,kg\,(-8\,m/s) + P_x$

$P_x = 10\,kg\,m/s + 8\,kg\,m/s = 18\,kg\,m/s$

c. What must be the kinetic energy of Ball X after the collision? Explain completely

In an elastic collision, total KE of the system is conserved.

Before = After

$0 + \frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_1 v_1'^2 + \frac{1}{2} m_x v_x^2$

$\frac{1}{2}(1\,kg)(10\,m/s)^2 = \frac{1}{2}(1\,kg)(8\,m/s)^2 + KE_x$

$50\,kg\,m^2/s^2 = 32\,kg\,m^2/s^2 + KE_x$

$KE_x = (50-32)\,kg\,m^2/s^2 = 18\,kg\,m^2/s^2 = 18\,J$

A

d. ***Only*** *if you have time:* Find the mass of ball X and the final velocity of ball X.

Using two equations, we can find both unknown

$P_x = m_x V_x$

$18\,kg\,m/s = m_x V_x$

$\frac{18}{V_x} = m_x$

$\Rightarrow V_x = 2\,m/s$

$m_x = \frac{18\,kg\,m/s}{2\,m/s}$

$= 9\,kg$

$KE_x = \frac{1}{2} m_x (V_x)^2$

$18\,J = \frac{1}{2} m_x (V_x)^2$

$18\,J = \frac{1}{2}\left(\frac{18\,kg\,m/s}{V_x}\right)(V_x)^2$

$18\,J = \frac{1}{2}(18\,kg\,m/s)\,V_x$

$36\,J = 18\,kg\,m/s \cdot V_x$

$V_x = \frac{36\,kg\,m^2/s^2}{18\,kg\,m/s}$

#4 A 1.0 kg ball moving at 10 m/s *to the right,* has a totally *elastic* collision with *stationary* "Ball X" of unkı mass, and *turns around moving to the left* at 8 m/s. We want to find the mass of Ball X, and its final velocity.

a. Without doing any math, can you tell me if the mass of Ball "X" is more or less than 1 kg? That is: fill in the space with <, >, or = : m_X **>** 1 kg
please give a reason

using a momentum lens,
the mass of X is heavier, and since momentum is conserved b/c no outside forces, b/c the 1kg hits it and travels in the opposite direction. If X was lighter the 1kg would hit X, and continue moving to the right

b. What must be the momentum of Ball X after the collision? Explain completely

momentum Lens.

$P_{1.0} = P_x$

$m_{1.0}V_{1_0} + m_xV_{x_0} = m_1V_{1_F} + m_xV_{x_F} \to P_x$

Right = (+)
Left = (−)

$(1kg)(10\frac{m}{s}) = (1kg \cdot -8\frac{m}{s}) + P_x$

$10\,kg\frac{m}{s} = -8\,kg\frac{m}{s} + P_x$

$\boxed{P_x = 18\,kg\,m/s}$

c. What must be the kinetic energy of Ball X after the collision? Explain completely.

Energy Lens b/c kinetic energy is conserved b/c elastic collision occurs. Energy is also conserved.

A

$KE_{1.0_0} = KE_{1.0_F} + KE_x$

$KE_x = KE_{1.0_0} - KE_{1.0_F}$

$KE_x = \frac{1}{2}mV_0^2 - \frac{1}{2}mV_F^2$

$KE_x = \frac{1}{2}m(V_0^2 - V_F^2)$

$KE_x = \frac{1}{2}(1kg)\left[(10\frac{m}{s})^2 - (-8\frac{m}{s})^2\right]$

$KE_x = \frac{1}{2}(1kg)(100\frac{m^2}{s^2} - 64\frac{m^2}{s^2})$

$KE_x = \frac{1}{2}(1kg)(36\frac{m^2}{s^2})$

$\boxed{KE_x = 18J}$

d. ***Only*** *if you have time:* Find the mass of ball X and the final velocity of ball X.

Both momentum and energy lens.

$P_x = m_xV_x = 18\,kg\,m/s$ $\quad KE_x = \frac{1}{2}m_xV_x^2 = 18J$

$\frac{KE_x}{P_x} = \frac{\frac{1}{2}\cancel{m_x}V_x^{\cancel{2}}}{\cancel{m_x}\cancel{V_x}} = \frac{1}{2}V_x = \frac{18J}{18\,kg\frac{m}{s}} = 1$

$\boxed{V_x = 2\frac{m}{s}\ \text{right}}$

$18\,kg\frac{m}{s} = 2\frac{m}{s}(m_x)$

$m_x = 9kg$