A

A 1. In Dubai, you visit the tallest building in the world, & select the "extreme" elevator. Near end of ascent, you're on the ceiling of elevator, upside down, on scale, which reads 100 N. Surprisingly, your mass is 50 kg.

(a)

$N = F_g = -500N$

$\vec{a} = 0\ m/s^2$

$\vec{v} = 0\ m/s$

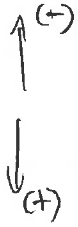
$F_g = mg = (50kg)(10m/s^2) = 500N$

I would use a dynamics lens for this since I see that there are forces here causing acceleration. On solid ground, just standing on the scale, it would read 500 N. The force of my feet on the scale, caused by gravity, must cancel out the normal force of the scale on me since I'm in static equilibrium. So, $N = F_g = mg = (50\ kg)(10 m/s^2) = \boxed{500N.}$

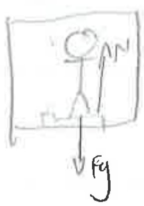
(b)

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

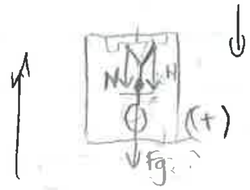
(+) $\Sigma\vec{F} = \vec{F_g} + \vec{N}$



(+)



$100N = N\ (+)$



$m\vec{a} = m\vec{g} + \vec{N}$

$(50kg)\vec{a} = +(50kg)(10m/s^2) + 100N$

$(50kg)\vec{a} = +600\ N$

$\vec{a} = \boxed{12\ m/s^2}$

good drawings

I would use a dynamics lens for this problem again since there's still forces causing an acceleration on my body. Since the scale reads 100 N, I know that the normal force is 100 N. My mass doesn't change so my force due to gravity is still $F_g = mg = (50kg)(10m/s^2)$ in the same direction; $-500N = F_g$. So, the net force would be the normal force plus the force due to gravity;

$\Sigma\vec{F} = \vec{N} + \vec{F_g} \Leftrightarrow m\vec{a} = \vec{N} + m\vec{g} \rightarrow (50kg)\vec{a} = 100N + (50kg)(+10m/s^2)$

Knowing this, I can solve for my acceleration $\vec{a}$, which ends up being $\boxed{\vec{a} = +12\ m/s^2}$ ✓

$PE = KE_1 + KE_2 + E_{th}$

$p = mv$ $v = \frac{p}{m}$ $\Sigma E = PE + KE$ $\Sigma E = PE + KE$ $KE_{high} = \frac{1}{2}mv^2$

ΣE

$m : m$

(P) (N)

A 2) Triton Deutron Helium $PE = KE$

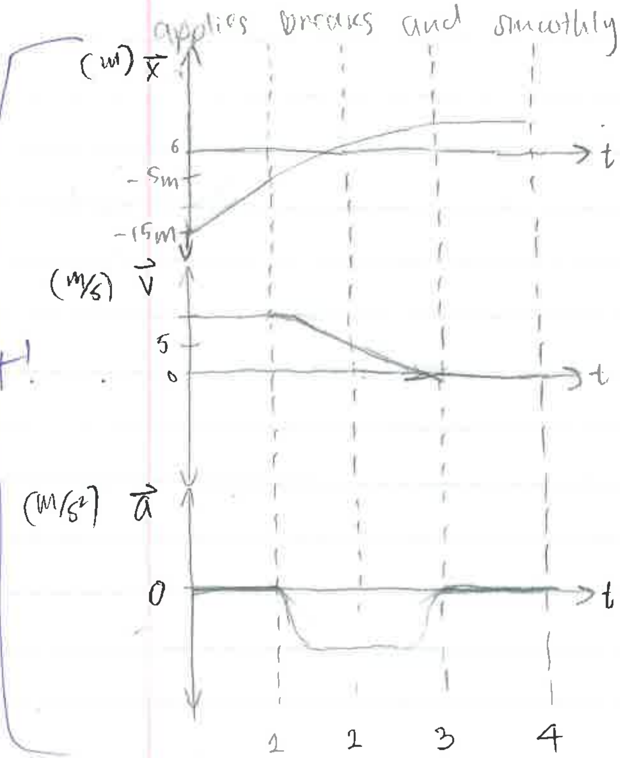
$\Sigma KE = KE_1 + KE_2 + E_{th}$
$= \frac{1}{2}mv^2 + \frac{1}{2}(4m)v^2$

m 4m

I would look at this problem through an energy lens since I can clearly see that there's a transformation of energy when the 5-nucleon nucleus breaks apart. Before the explosive breakup, I can see that all energy in the 5-ball cluster is stored as potential energy PE. Post breakup, the energy of the system is not conserved, assuming energy was lost as heat E_{th}. As for the remaining kinetic energy, we first use a momentum lens, since the force between them acts equally on each, they each experience the same impulse. However, knowing that $p = mv$, we know that the one with smaller mass will reach a higher velocity. So, given that $W = F \cdot dx = \frac{1}{2}mv^2$, the single neutron must have more kinetic energy in the end.

Great, now do the math on the factor.

2.3 #1 A 3) $m_{pete} = 70\,kg$, $m_{bike} = 10\,kg$. Pete's riding at constant $10\,m/s$. At 0s, his displacement is $x = -15\,m$, he sees a car. At $t = 1s$, he applies breaks and smoothly slows to a stop over period of 2 sec.



perfect!

a) I would use a kinematics lens to solve this problem because I'm analyzing Pete's motion as explicit functions of time.

b) Graph $\vec{a}, \vec{v}$, and $\vec{x}$ as function of time.

c) I would use a dynamics lens for this since I see that a force causes acceleration.

$$\vec{a} = \frac{v_f - v_0}{t_f - t_0} = \frac{0\,m/s - 10\,m/s}{3s - 1s} = \frac{-10\,m/s}{2s} = -5\,m/s^2$$

$$\vec{F} = ma = (m_{pete} + m_{bike})\,a$$

$$\vec{F} = (70\,kg + 10\,kg)(-5\,m/s^2)$$

$$\vec{F} = -400\,kg \cdot m/s^2 = \boxed{-400\,N}$$

d) I would use a energy lens to solve this since to find work, I need to see how energy is transformed in the system. We know that work is a change in energy which is $W = dE = F \cdot dx$, with F being force and Δx being displacement. We found the force of the breaks already, and integrating the velocity vs. time graph (finding the area under the curve), his displacement over the 2 seconds that he used his breaks is about: $\frac{1}{2}vt = \frac{1}{2}(10\,m/s)(2s) = 10\,m$.

~~we don't know exactly because the curve~~ nevermind.

Honestly energy lense is easier.

So, $W = \vec{F} \cdot d\vec{x} = (-400\,N)(10\,m) = -4000\,N \cdot m = \boxed{-4000\,J.}$

We know that power is the rate of change of energy; $P = \frac{dE}{dt} = \frac{W}{dt} = \frac{-4000\,J}{2\,s} = \boxed{-2000\,W}$.

$\frac{1}{2}(m)(v^2) \to 0 = \Delta E = W$

e) I would use an energy lens for this again since energy is being transformed. The potential energy of the breaks wasn't all converted to kinetic energy when it was used; a lot of it was converted (through friction) to thermal energy E_{th} and "lost" to the surroundings. Therefore, energy was not conserved in the process.

(*) f) I would use a momentum lens for this since I'm analyzing whether or not momentum is conserved, especially since there were no outside forces acting on this system. Without any outside forces, momentum is conserved; the bike's wheels and the ground (the Earth, essentially) each experience equal and opposite impulses. Since the bike and Pete have a much smaller mass than the Earth, their change in velocity is much more noticeable than Earth's.

$KE = \frac{1}{2}mv^2$

$W = F \cdot dx$

(+)

2.7 F15 B+ 4) Graph of PE as function of displacement. $m = 2\ kg$. (pos. x is to the right).
Mass starts at $x=0$ moving @ $2\ m/s$ to the left. (Got all correct ans.)

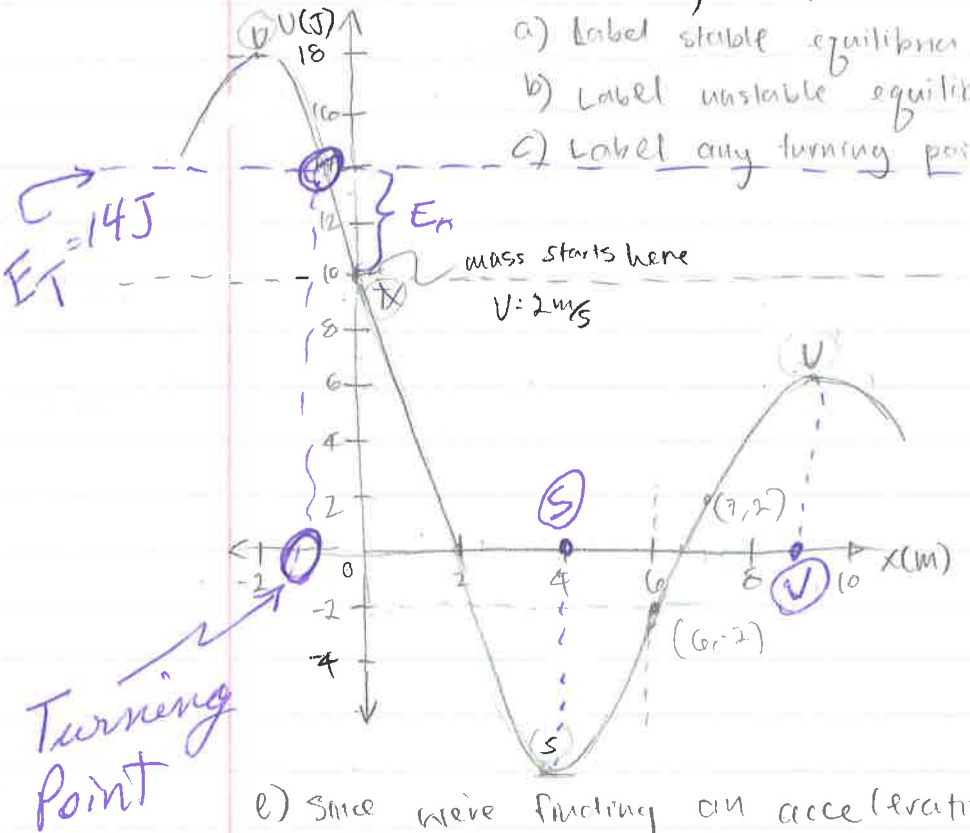
a) Label stable equilibria w/ "S"

b) Label unstable equilibria w/ "U"

c) Label any turning points w/ "T"

$E_{P_0} = 10J$

$EK_0 = \frac{1}{2}mv^2 = 4J$



d) Where does block attain highest speed, & what is this V_{max}?
I would use an energy lens for this since it involves a transformation of energy. The block has highest speed where PE is the lowest & KE is the highest; at 4m.
calculate...

e) Since we're finding an acceleration, I would use a dynamics lens since I would need to consider a force that causes that acceleration. I would also use an energy lens since I can also consider that force is the negative gradient of potential energy; $F = \frac{-dE}{dx}$. So,

the force $x = 6m$, the force is approximately $\vec{F} = \frac{-[2J - (-2J)]}{7m - 6m} = -4\frac{J}{m} = -4N.$

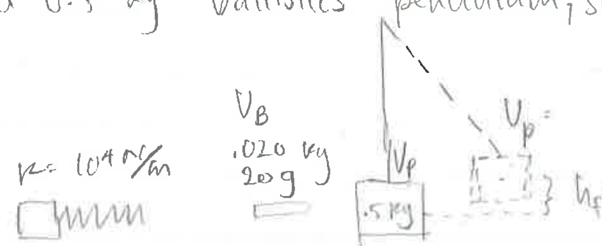
Since $\vec{F} = m\vec{a}$, then; $\vec{a} = \frac{\vec{F}}{m} = \frac{-4N}{2\ kg} = -2\frac{N}{kg} = \boxed{-2\ m/s^2}$ in the negative direction. nice!

B 5) An object starts at $10\ m$ (x_0) w/ speed of $5\ m/s$ (v_0) & has accel. of $-4\ m/s^2 + 2\ m/s^3\ (t)$. Find velocity & position after 3 sec.

I would use a kinematics lens to solve this since I see an object's motion as an explicit function of time. At $t=3$, $a(3) = -4\ m/s^2 + 2\ m/s^3 (3s) = 2\ m/s^2$.

We know that $\vec{a} = \frac{\Delta V}{\Delta t} \Rightarrow \Delta \vec{V} = \vec{a}\Delta t = (2 m/s^2)(3s) = 6\ m/s$, which is the change in velocity after 3 sec. But, the object started at $5\ m/s$, so $V_f = 5\ m/s + 6\ m/s = \boxed{11\ m/s}$. We also know that $x = x_0 + Vt$, so $x = (10m) + (11 m/s)(3s) = 10m + 33m = \boxed{43m}$ which is the final position of the object after 3 sec.

A 6) A loaded gun is cocked by compressing a spring of $k = 10^4\ N/m$ then releasing it behind a $20g$ bullet. The bullet strikes & sticks inside a $0.5\ kg$ ballistics pendulum, swings up to $50\ cm$. Spring is massless, no friction.



$h_f = 50\ cm = .50m$

$PE_{bullet + pendulum} = mgh$
$= (.02 kg + .5 kg)(10 m/s^2)(.50m) = 2.6 J$

a) I would use an energy lens to find the speed of the bullet w/ the pendulum first since I see a transformation between kinetic KE and potential PE. As the bullet and pendulum rise up, they gain PE, and since there's no energy lost to friction, then $PE = KE \rightarrow m_{B+P}\, g\, \Delta h = \frac{1}{2} m_{B+P} V_{B+P}^2 \rightarrow V_{B+P} = \sqrt{2g\Delta h}$

$V_{B+P} = \sqrt{2(10 m/s^2)(0.5m)} = \sqrt{10\ m^2/s^2} \approx 3.16\ m/s$, which is the velocity of the bullet and pendulum together.

With a momentum lens, we see that since the bullet sticks to the pendulum, then $P_B + P_P = P_{B+P} = M_B V_B + M_P V_P = (M_B + M_P) V_{B+P}$

Since V_P is initially zero, then $M_B V_B = (M_B + M_P) V_{B+P}$

$V_B = \frac{(m_B + m_P) V_{B+P}}{m_B} = \frac{(0.02\ kg + 0.5\ kg)(3.16\ m/s)}{(0.02\ kg)} \approx \boxed{82.21\ m/s}$

b) How far was the spring compressed?

I would use an energy lens for this since I see that energy is transformed from the spring to the bullet. Since no energy is lost to friction, the energy of the spring is equal to the energy that the bullet gains; $E_s = KE_B$. We know $E_s = \frac{1}{2}kx^2$ and $KE = \frac{1}{2}mv_B^2 \rightarrow \frac{1}{2}kx^2 = \frac{1}{2}mv_B^2 \rightarrow$

$$x = \sqrt{\frac{mv_B^2}{k}} = \sqrt{\frac{(0.02\,kg)(82.21\,m/s)^2}{10^4\,N/m}} = 0.116\sqrt{\frac{kg \cdot \frac{m^2}{s^2}}{\left(kg \cdot \frac{m}{s^2}\right)/m}} = \boxed{0.116\,m},$$

which is how far the spring was compressed.

c) Does the bullet have constant accel. in the gun, or does it change over time?

I would use a dynamics lens because I'm analyzing how the force of the spring affects the bullet's acceleration. The acceleration of the bullet changes over time because the force changes as the spring is released. We know this from Hooke's Law: $\vec{F} = k\vec{x}$, where $\vec{x}$ is how far the spring's end is displaced. Since $\vec{x}$ affects $\vec{F}$, and $\vec{F} = m\vec{a}$, then the acceleration does change as the spring is released.

(*) d) Find the maximum acceleration of the bullet in the gun.

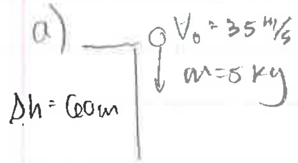
I would use a dynamics lens for this because I'm analyzing forces (of the spring) accelerating the bullet. Through Hooke's law, $\vec{F} = k\vec{x}$, we can find the force of the spring on the bullet:
$\vec{F} = k\vec{x} = (10^4\,N/m)(0.116\,m) = 1162.8\,N$. Since $\vec{F} = m\vec{a}$,

$E_s = \frac{1}{2}kx^2$
$= \frac{1}{2}(10^4\,N/m)(0.116\,m)^2$
$= 67.28\,J$

$W = F \cdot \Delta x = ma \cdot \Delta x$
$67.28 = (0.02\,kg) \cdot a \cdot (0.116\,m)$
$a \cdot$

A 7) Using energy lens, show that if you drop a 5 kg box from 60m, it hits the ground at ~35 m/s. But then you throw the box downward from 60m height w/ initial speed of 35 m/s.

a)



Using an energy lens, we know that if the box was just dropped, all it's PE at 60 m would transform to KE at the bottom:

$$PE = KE \rightarrow \cancel{m}gh = \tfrac{1}{2}\cancel{m}V^2 \rightarrow V = \sqrt{2gh}$$

$$= \sqrt{2(10\,m/s^2)(60\,m)} \approx \boxed{35\ m/s}$$

However, if the box was thrown with an initial velocity $V_0 = 35$ m/s, it's total energy initially would be its gravitational potential PE_g plus the KE from my throw; $\Sigma E_i = PE_g + KE = mgh + \frac{1}{2}mV^2$. When it hits the ground, the box's energy will be only $KE = \frac{1}{2}mv^2$. Therefore:

$$PE_g + KE_i = KE_f$$

$$mgh + \tfrac{1}{2}\cancel{m}V_i^2 = \tfrac{1}{2}\cancel{m}V_f^2$$

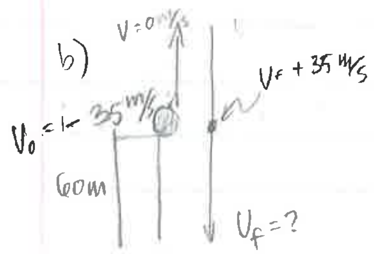
$$2gh + V_i^2 = V_f^2$$

$$V_f = \sqrt{2gh + V_i^2}$$

$$V_f = \sqrt{2(10\,m/s^2)(60\,m) + (35\,m/s)}$$

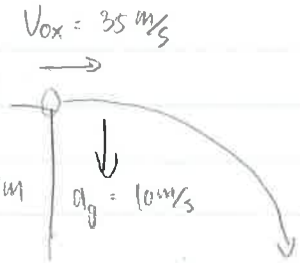
$$V_f \approx 49.24\sqrt{\frac{m^2}{s^2}} = \boxed{49.24\ m/s}$$

b)



I would use a kinematics lens again since I'm still analyzing the box's motion over time. If I threw the ball upward at -35 m/s, upward being the negative direction, it would come back at to the level at which I threw it at +35 m/s, since velocity is displacement over time and the displacement up until that point is zero. From there, it would drop 60 m with at same initial velocity and still land at v = 49.24 m/s.

c)



I would use a kinematics lens for this since I'm looking at motion over time. I know that the horizontal component of the box's velocity is independent of the vertical component, so the ball's downward's acceleration is due to gravity = $10 \, m/s$ only. So, the ball descends in the y-direction with an initial velocity $\hat{y}$ of $V_{oy} = 0 \, m/s$, as if it was being dropped. So, the ball should hit the ground with a vertical velocity of $35 \, m/s$ as calculated before. However, the resultant of the horizontal component of the box's velocity $V_{ox} = 35 \, m/s$ and the vertical component $V_{oy} = 35 \, m/s$ is $V_R = \sqrt{(35 \, m/s)^2 + (35 \, m/s)^2} = \cancel{\boxed{49.5 \, m/s}}$

Just think vertical speed

d) can I throw a 5 kg box at $35 \, m/s$?

I would use a dynamics lens for this because I want to see the required force to accelerated a box to a certain velocity. To put this in more realistic terms, 5 kg is around 11 pounds and 35 m/s is around 78 mph. $F = ma = m \cdot \left(\frac{\Delta V}{\Delta t}\right) = (5kg)\left(\frac{35 \, m/s}{1 \, s}\right) = 175N$

To accelerate a 5 kg mass to $35 \, m/s$ in one second requires 175 N of force, or about 40 lbs.