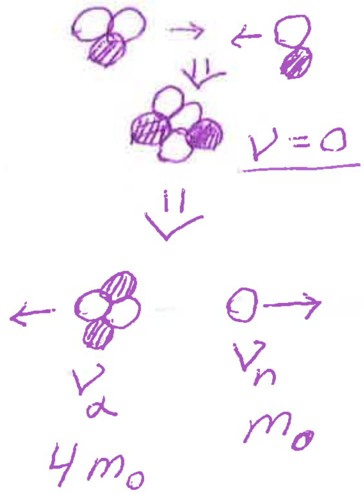
Midterm #1, 141, Schwartz Name Peto Graded on ***COMMUNICATION*** of physics 8:58

1) Fusion is the process that powers the sun and hydrogen bombs: small nuclei are fused into larger nuclei. One fusion process involves a triton (two neutrons and a proton) and a deuteron (one neutron and a proton) fusing to form a supercharged 5-nucleon nucleus, which gives off its energy by breaking up into a single neutron and a helium nucleus (or alpha particle) at high speeds. I want to know which of the particles gets more of the energy. Let's simplify the problem to just the explosive breakup: Protons and neutrons have the same mass, so we can think of this process as **a 5-ball cluster (in space, at rest) breaking up into one ball and a 4-ball cluster. Do the two pieces equally share the kinetic energy or does one get all or more kinetic energy?** You will be graded not on your answer, but on your reasons, drawings, and lens descriptions.



I'm going to consider this through a $\vec{p}$ lense. $\Delta\Sigma\vec{p}=0$

← $\vec{p}_0=0$ because $v=0$ so

$\vec{p}_\alpha=-\vec{p}_n$

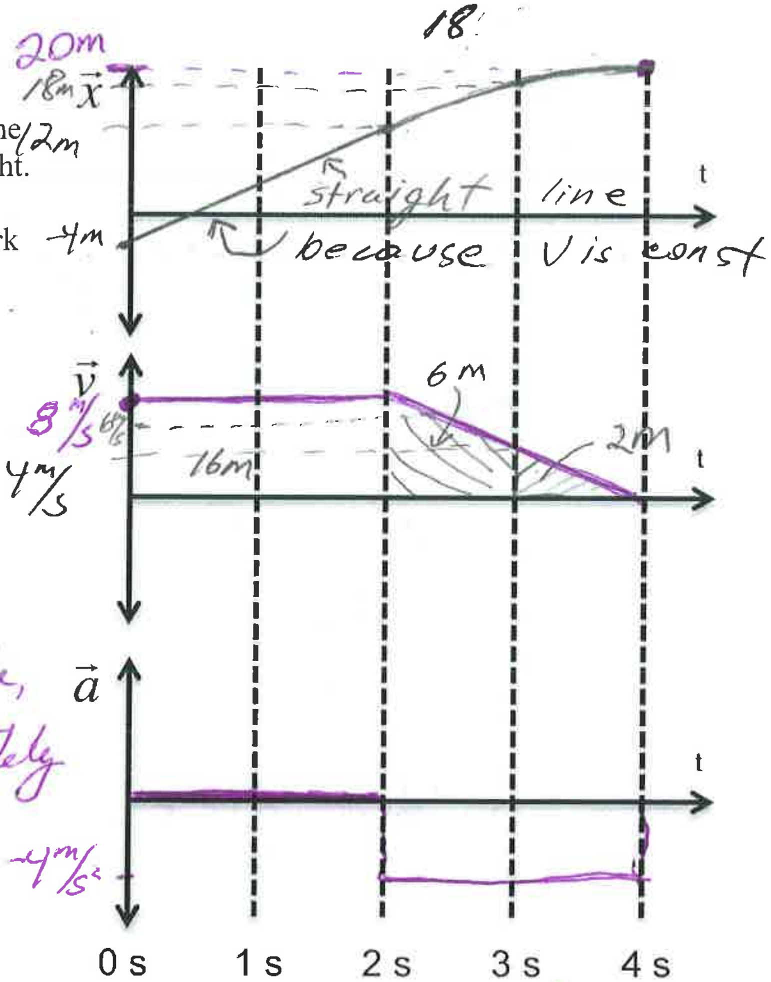
Because $m_\alpha=4m_n$
$v_\alpha=\frac{1}{4}v_n$ ②

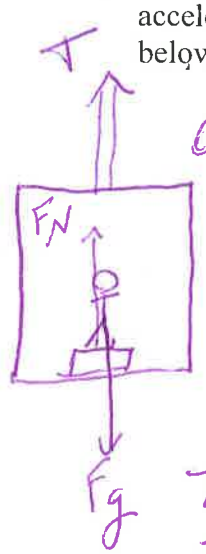
now I can compare their $KE=\frac{1}{2}mv^2$ to see that $KE_n=4KE_\alpha$. An easier way to express this is $KE=\frac{p^2}{2m}$. Because $|p|$ is the same.

in conclusion: they have =, opposite $\vec{p}$ and the KE of the neutron is 4 times the KE of the alpa particle.

2) My friend at mass 50 kg is on a scale in an elevator headed upwards at a constant speed of 8 m/s until t = 2s. Over the next two seconds, the elevator smoothly comes to a stop at 20 m height.

a) Please make the displacement, velocity, acceleration graphs at right. Show your work below, including lens explanation





$0s < t < 2s$ $a = 0$

$V = 8 m/s$ ⇈

$2s < t < 4s$ $a =$ ⇊

$V_f = 0$

The stuff in purple, I can do immediately

Then I switch to pencil

$a = \frac{dV}{dt} = \frac{-8 m/s}{2s} = -4 m/s^2$

$V = \frac{dx}{dt}$ so $dx = V dt$ = area under V↔t graph

then I worked backwards from x = 20m @ t = 4s by subtracting 2m, 6m, 16m.

b) Please calculate what the scale reads under my friend at t = 1 s, and at t = 3 s. Include discussion of lens and drawing

Refer to drawing above: its a FBD

This is a dynamics problem .... "OH Joy!" I know what to do: $\sum \vec{F}_{girl} = m\vec{a}_{girl}$ $\vec{F}_N + F_g = ma$

question: "She's accelerating ⇊, so I define ↓ as the Positive direction. Consequently, so I draw a $\sum \vec{F}$ diagram

$|F_g| > |F_N|$ because a ⇊

how much? $ma = 50 kg (4 m/s^2) = 200 N$

so reading on the scale $= F_N = F_g - 200N = 300N$

or scale reads 30 kg if it reads in assumed mass.

3) Dragsters have a mass of about 1000 kg and the best get to 44 m/s in about 0.8 s.

a) What's the acceleration?

b) Estimate the coefficient of friction necessary to make this happen in a regular car on a flat level road.

c) What's the average power output during this 0.8 s?

d) Dragsters have their exhaust pipes pointed *upwards*, which ejects a huge amount of exhaust at very high velocity *up into the air*. What effect does this thrust have on the coefficient of friction necessary to accelerate the car? *Why?*

For all parts, please start with clarification of reasons, drawings, lenses.

$v_0 = 0$ $v_f = 44\,m/s$ $\Delta t = 0.8\,s$

a) a = ? This is about motion + time so kinematics

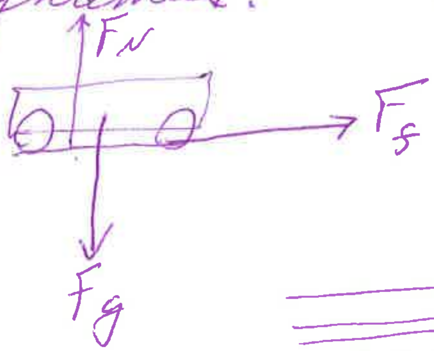
$a = \frac{\Delta v}{\Delta t} = \frac{44\,m/s}{0.8\,s} = 55\,m/s^2$ or $5.5g$ wow!

b) We know a, and want to know force... so we use dynamics.

$\Sigma F_y = ma_y = 0$, so $F_N = F_g = mg$

$\Sigma F_x = ma = m \cdot 5.5g = F_f$

$F_f = \mu F_N$ $\mu = \frac{F_f}{F_N} = 5.5$ (wow)



$\Longrightarrow F_f$ (There's only 1 F_x)

$\Longrightarrow \Sigma F = ma$

c) Energy lens because $P = \frac{\Delta E}{\Delta t} = \frac{E_f - E_0}{\Delta t}$ ($E_0 \to 0$)

we are only looking at $KE = \frac{1}{2}mv^2 = \frac{1}{2}(1000\,kg)(44\,m/s)^2$

$= 968\,kJ$

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176
$1936\,m^2/s^2 \times \frac{1}{2} = 968\,m^2/s^2$

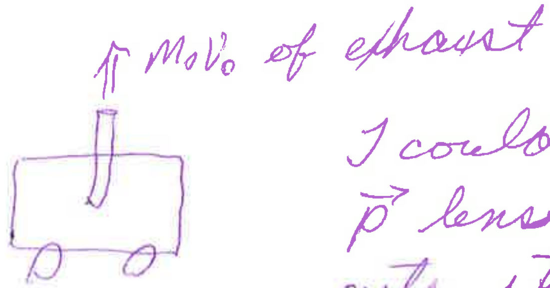
$kg\frac{m^2}{s^2} = J$ $P = \frac{968\,kJ}{.8\,s} = 1210\,kW$

$\approx 1600\,HP$

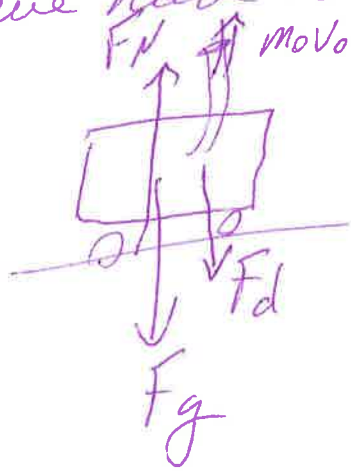
like 10 regular cars

d) see other side

3d)



I could look at this through $\vec{p}$ lens: the gas starts at rest + gets $\Delta \vec{P}$ ⇑ exchanging $\vec{p}$ w/ car so car gets $\Delta \vec{p}$ ⇓. ~~or~~ you could use dynamics The F ⇑ to accelerate the gas upward = F ⇓ on the car because it's the same force. Either way, this creates a ⇓ force on the car. now we have ~~also~~ another term in the $\Sigma \vec{F}_y = m\vec{a}_y = 0$



$F_d = \frac{m_0 V_0}{\Delta t}$

so now F_N ⇑, $F_N = F_g + F_d$

recall $F_f = \mu F_N$, so if F_N ⇑, μ can be less!