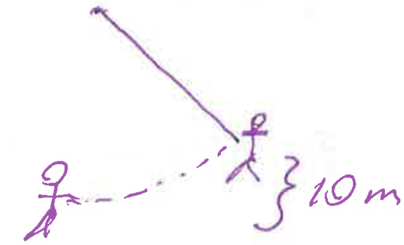
Midterm #1, 141, Schwartz Name Pete Graded on ***COMMUNICATION*** of physics

1) Jane (50 kg) standing on a tree limb spots Tarzan (100 kg) down below, and it's not going well for him, standing motionless among a group of hyenas. She rescues him by grabbing a frictionless vine and swinging down 10 m from the limb she is on in a circular arc like on a swing. At the bottom of her swing, she is moving horizontally and runs into Tarzan with a *THUD* and proceeds to hold him with one arm while holding the vine with the other arm.
   a) How fast are the two of them going after she grabs him?
   b) Is mechanical energy (KE+PE) conserved in this process? If so, how do you know? If not, what portion of the energy is lost?



I know to use the energy lens because Jane's KE is equal to the PE she loses.

However, Energy isn't conserved in the (inelastic collision) so I'll use momentum there

$KE_J = PE_{0J}$

$\frac{1}{2}\cancel{m_J}v^2 = \cancel{m_J}gh$

$v = \sqrt{2gh}$

$= \sqrt{2 \cdot 10 m/s^2 \cdot 10 m}$

$= \sqrt{2} \cdot 10 m/s \approx 14 m/s$

In collision,

$m_J \to m_J + m_T = 3m_J$

~~if m~~ conserve $\vec{p}$:

$p = mv$, so if

$m \Rightarrow 3m_0$, $v \Rightarrow \frac{1}{3}m_0$

$v_f \approx \frac{14 m/s}{3} \approx 4\frac{2}{3} m/s$

2) A 2000 kg truck has an engine that accelerates it from 20 m/s to 35 m/s in 5 seconds.

a) Find the average force that the wheels must provide.

This is both a dynamics & kinematics because $F = ma$, but I used $a = \frac{\Delta V}{\Delta t}$

$$a = \frac{15\,m/s}{5\,s} = 3\,m/s^2$$

$$F = ma = 2000\,kg \cdot 3\,m/s^2 = 6000\,kg\,m/s^2$$
$$= 6000\,N$$

b) Find the average power the engine provides during this 5 seconds.

I'm going to use Energy lens because

$$P = \frac{\Delta E}{\Delta t} \quad \left(\text{also} = \frac{W}{t}\right)$$

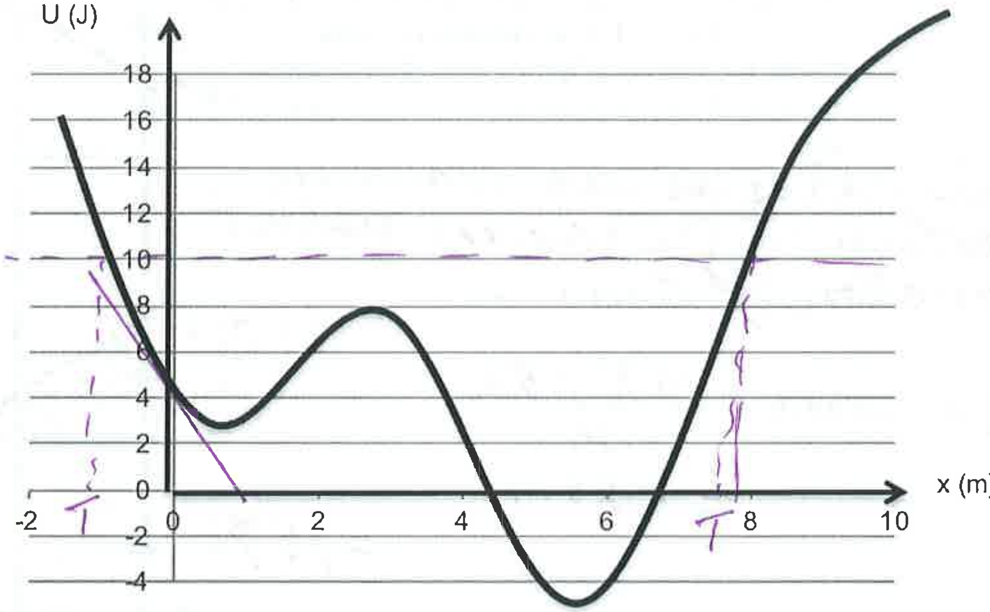
change in energy is kinetic energy because it speeds up

$$= \frac{\frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2}{\Delta t}$$

$$= \frac{\frac{1}{2}(2000\,kg\left[(35\,m/s)^2 - (20\,m/s)^2\right]}{5\,s} \approx 165\,kW$$

$$\frac{kg\,\frac{m^2}{s^2}}{s} = \frac{J}{s} = W$$

3. At right, you see a potential energy diagram for a 3 kg mass, as a function of its displacement. (positive x is to the right). The mass is released at x = 0 m moving at 2 m/s to the right.



a) Is the mass accelerating at this point (x = 0) immediately after release? If not how do you know? If so, estimate the acceleration.

I'm using Energy lens for all of these because its a PE graph. gradient of Potential energy

$F = -\frac{d(PE)}{dx}$ $\quad \frac{\Delta Y}{\Delta X} \approx \frac{-4J}{1m} = -4N$ $\quad \underline{\vec{F} = 4N \text{ in } +x \Rightarrow}$

$a = \frac{F}{m} \approx \frac{4N}{3kg} \approx 1.3 \frac{\cancel{kg}\,m/s^2}{\cancel{kg}} = 1.3\ m/s^2$

b) Are there any turning points, if not, how do you know? If so, please indicate where they are by placing a "T" at those points. must find Total energy = PE + KE

at $t = 0$ $\quad V = 2\,m/s$, $KE = \frac{1}{2}(3kg)(2\,m/s)^2 = 6\,J$ $\quad E_T = 4J + 6J = 10J$

c) Is the mass in equilibrium at any point(s) in time? If not, how do you know? If so, please indicate where are the stable equilibrium points, and where are the unstable equilibrium points by placing a "S" or a "U" at those points.

a = 0, F = 0, so no slope...

d) Where does the 3 kg mass achieve its maximum speed? KE is highest when PE is lowest
$x \approx 5.7m$

e) Calculate the maximum speed that the 3 kg mass achieves.

Total E = PE + KE = 10J $\qquad$ PE = -5J @ x = 5.7m

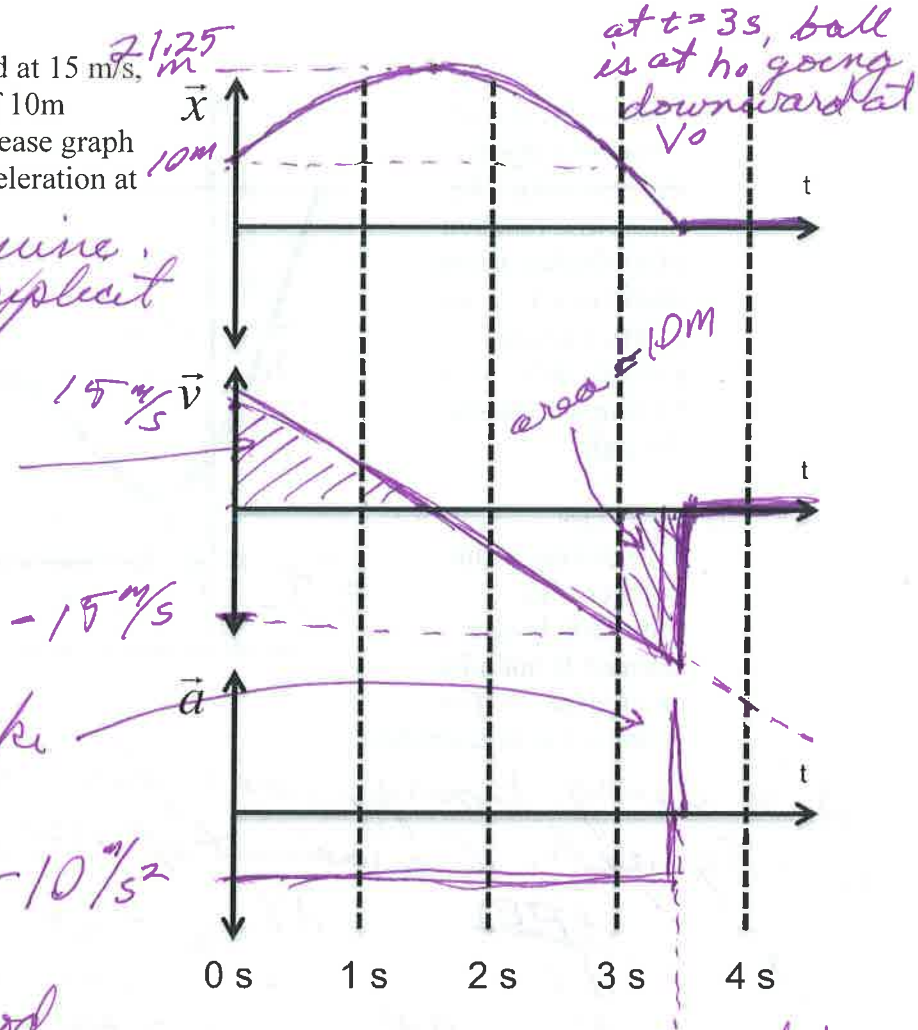
$KE = 10J - PE$

$= 15J = \frac{1}{2}mV^2$ $\qquad V = \sqrt{\frac{2 \cdot 15J}{3kg}}$

V_{max} $\boxed{\approx 3.3\ m/s}$

{ we have a turning Pt when KE = 0, or Total E = PE
{ x ≈ -1m, ≈ 8m

4) I throw an object directly upward at 15 m/s, it leaves my hand at an elevation of 10m above the ground (I'm in a tree). Please graph the velocity, displacement, and acceleration at right.



Kinematics as we examine motion $(\vec{x}, \vec{v}, \vec{a})$ as an explicit function of time.

$$\Delta x = \text{area} = \frac{15\,m/s \cdot 1.5\,s}{2}$$

$$\approx 11.25\,m$$

There is a huge spike in $\vec{a}$ because velocity increases (goes to $v=0$) in an incredibly short period of time when ball hits.

ball hits ground + stops.

5) If an object starts at a displacement of -20 m, and has a velocity of $v(t) = 5\frac{m}{s} - 2\frac{m}{s^2}(t) + 1\frac{m}{s^3}(t^2)$, please find the displacement and acceleration at t = 4s.

Kinematics because we are trying to find motion $(\vec{x}, \vec{a})$ at a given time.

$$a = \frac{dv}{dt} = 0 - 2\,m/s^2 + 2 \cdot 1\,\frac{m}{s^3}\,t$$

$$a(t=4s) = -2\,m/s^2 + 2\,m/s^3(4s) = -2\,m/s^2 + 8\,m/s^2 = 6\,m/s^2$$

$$x(t) = x_0 + \int_0^t v(t)\,dt = x_0 + 5\,m/s\,t - 2\,m/s^2\,\frac{t^2}{2} + 1\,m/s^3\,\frac{t^3}{3}$$

$$x(4s) = -20m + 5\,m/s(4s) - \frac{2\,m/s^2}{2}(4s)^2 + \frac{1\,m/s^3}{3}\,64\,s^3$$

$$\approx 5.3\,m$$