Solutions posted

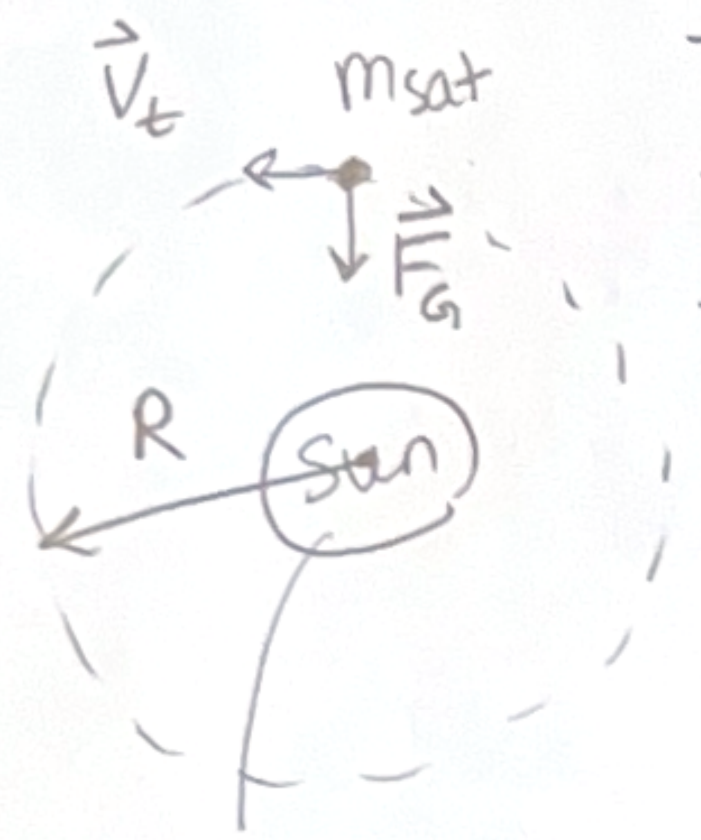
10

Name: ____________

Date: ____________

Momentum Application 1

1. p.354 #27 Show work



$M_s = 1.99\times10^{30}$ kg

$T = 1.0$ day

$T = 24h\left(\frac{3600s}{1h}\right)$

$T = \boxed{8.64\times10^4 s}$

$V_t = \frac{\Delta s}{\Delta t}$

$V_t = \frac{2\pi R}{T}$

- Energy conservation is not useful because nothing is changing.
- Let's try circular motion!

$a_r = \frac{\Sigma F_r}{m}$

$\frac{V_t^2}{R} = \frac{\left(\frac{G M_s \cancel{m_{sat}}}{R^2}\right)}{\cancel{m_{sat}}}$

$V_t^2 = \frac{G M_s}{R^2} \cdot R$

$V_t^2 = \frac{G M_s}{R}$

Now put in V_t:

$\left(\frac{2\pi R}{T}\right)^2 = \frac{G M_s}{R}$

$\frac{4\pi^2 R^2}{T^2} = \frac{G M_s}{R}$

$R^3 = \frac{G M_s T^2}{4\pi^2}$

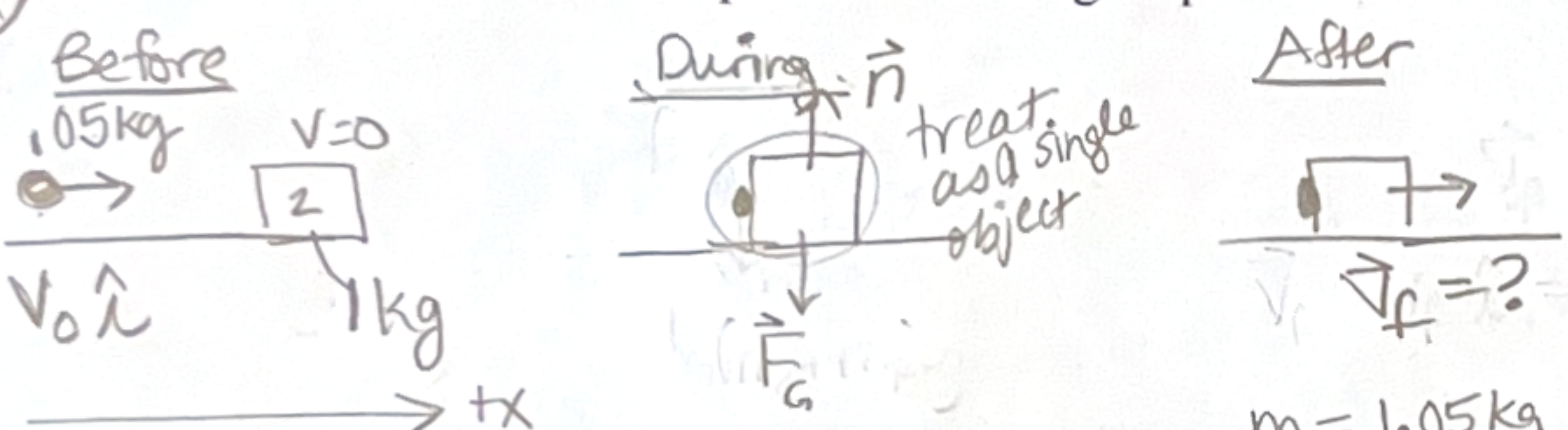
$R = \sqrt[3]{\frac{(6.67\times10^{-11}\frac{Nm^2}{kg^2})(1.99\times10^{30}kg)(8.64\times10^4 s)^2}{4\pi^2}}$

$R = \sqrt[3]{2.50984\times10^{28}}$

$\boxed{R = 2.9m}$

2. p.287 #24 Show the problem-solving steps

(a)



$\vec{V}_i = V_0\hat{i}$

+x

$\vec{V}_f = ?$

$m = 1.05$ kg → because the clay & brick are now stuck together.

Clay
Brick

Ext force + Impulse:

$\vec{n} \Rightarrow \vec{J}_n$ cancel

$\vec{F}_G \Rightarrow \vec{J}_{F_G}$

So, $\Sigma\vec{J} = 0$

momentum conservation vector diagram

$\vec{p}_i + \Sigma\vec{J} = \vec{p}_f$

$\longrightarrow + 0 = \longrightarrow$

Before	$\vec{p}_i = m\vec{v} = (.05kg)(V_0\hat{i}) = .05kg\,V_0\hat{i}$
During	$\Sigma\vec{J} = 0$
After	$\vec{p}_f = (1.05kg)\,\vec{V}_f\hat{i}$

solving: $\vec{p}_i + \Sigma\vec{J} = \vec{p}_f$

$.05kg\,V_0\hat{i} + 0 = (1.05kg)\vec{V}_f$

$.0476V_0\hat{i} = \vec{V}_f$

The velocity is $.0476V_0\hat{i}$, so the speed is $\boxed{.0476V_0}$.

verify:

$\vec{p}_i + \Sigma\vec{J} = \vec{p}_f$

$\vec{p}_i$	$\vec{p}_f$
$\overrightarrow{.05kg\,V_0}$	$\vec{p}_f = m\vec{v}_f$ $= (1.05kg)(.0476V_0\hat{i})$ $= .05kg\,V_0\hat{i}$ $\overrightarrow{.05kg\,V_0}$

same!

p.287 #24 (b)

What % of mechanical energy is lost?

- mechanical energy = K + U
- U = 0 because y = 0.
- So I need to find $K_f - K_i$

Find K_i: $K_i = \frac{1}{2} m_c v_i^2 = \frac{1}{2}(.05\text{kg})(v_0)^2 = .025 v_0^2$

Find K_f: $K_f = \frac{1}{2}(m_c + m_B) v_f^2 = \frac{1}{2}(.05\text{kg} + 1.0\text{kg})(.0476 v_0)^2 = .00119 v_0^2$

Find K_{lost} = $K_f - K_i = .00119 v_0^2 - .025 v_0^2 = -.02381 v_0^2$

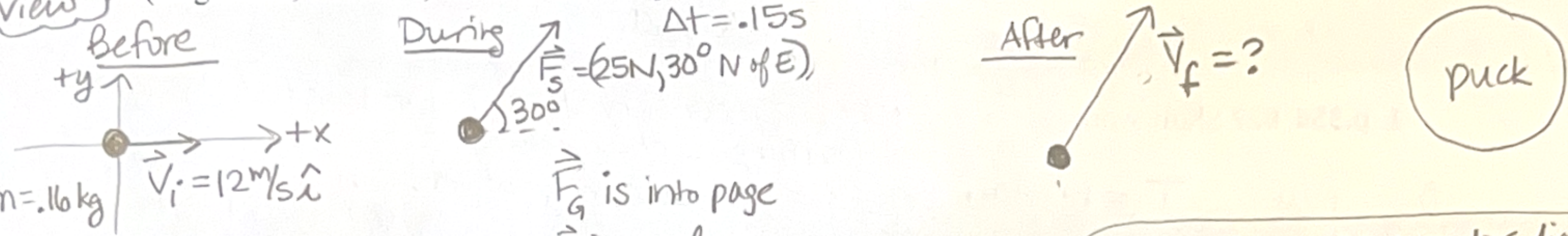
So the amount lost was $.02381 v_0^2$.

Find % of $E_{initial}$: What % is this of the original mechanical energy?

$$\frac{K_{lost}}{K_i} \times 100 = \frac{.02381 \cancel{v_0^2}}{.025 \cancel{v_0^2}} \times 100 = \boxed{95\%}$$

3. A 160 g hockey puck is sliding to the east with a speed of 12 m/s when it is struck by a hockey stick that exerts an average force of 25 N at an angle of 30° north of east for 0.15 s. What is the velocity of the hockey puck after it is struck? Express your answer in unit vector notation and in (magnitude, direction) form. Show the problem-solving steps.

Aerial view



$\vec{F}_G$ is into page
$\vec{n}$ is out of page

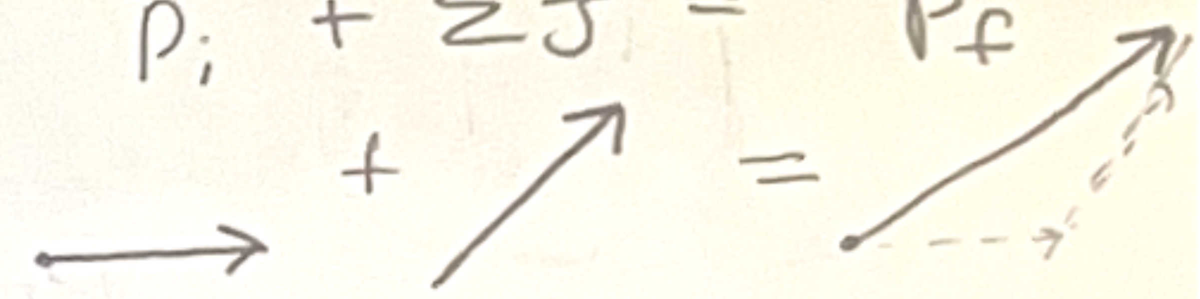
Ext Forces + Impulse:
$\vec{F}_s \Rightarrow \vec{J}_s$: significant
$\vec{F}_G \Rightarrow \vec{J}_{F_G}$: cancels
$\vec{n} \Rightarrow \vec{J}_n$:

Write $\vec{F}_s$ in unit vector notation:

$\vec{F}_s = +(25N\cos 30°\hat{i}) + (25N\sin 30°\hat{j})$
$\vec{F}_s = 21.65N\hat{i} + 12.5N\hat{j}$

momentum cons. vector diagram

$\vec{p}_i + \Sigma\vec{J} = \vec{p}_f$



Before	$\vec{p}_i = m\vec{v}_i = (.16\,kg)(12\,m/s\,\hat{i}) = 1.92\,kg\,m/s\,\hat{i}$
During	$\vec{J}_s = \vec{F}_{avg}\cdot\Delta t = (21.65N\hat{i} + 12.5N\hat{j})(.15s) = 3.25Ns\,\hat{i} + 1.875Ns\,\hat{j}$
After	$\vec{p}_f = m\vec{v}_f = (.16\,kg)\vec{v}_f$

$\vec{p}_i + \Sigma\vec{J} = \vec{p}_f$

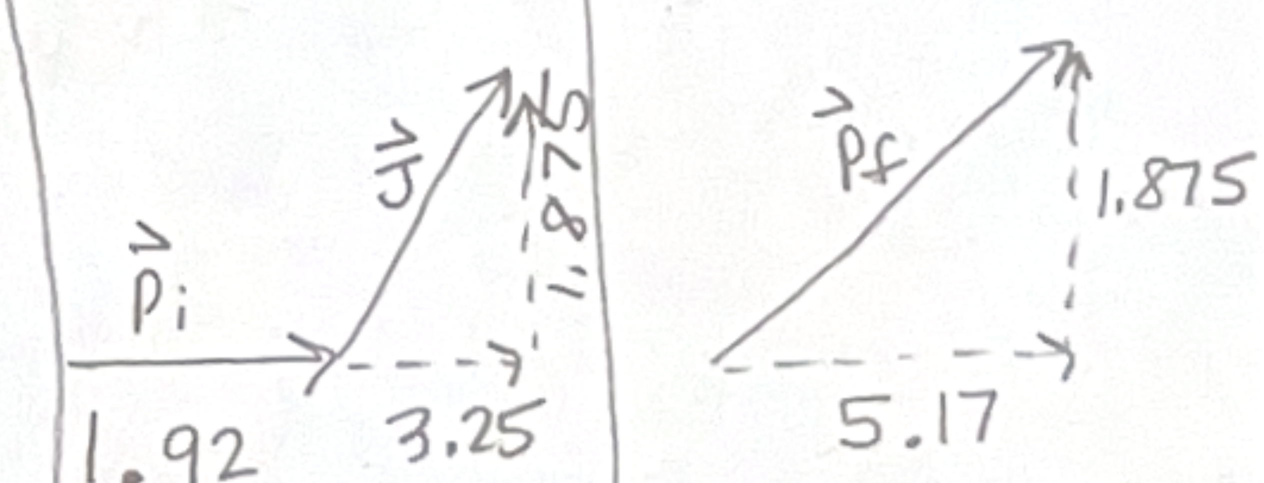
$1.92\,\frac{kg\,m}{s}\hat{i} + (3.25Ns\,\hat{i} + 1.875Ns\,\hat{j}) = (.16\,kg)\vec{v}_f$

$5.17\,\frac{kg\,m}{s}\hat{i} + 1.875\,\frac{kg\,m}{s}\hat{j} = (.16\,kg)\vec{v}_f$

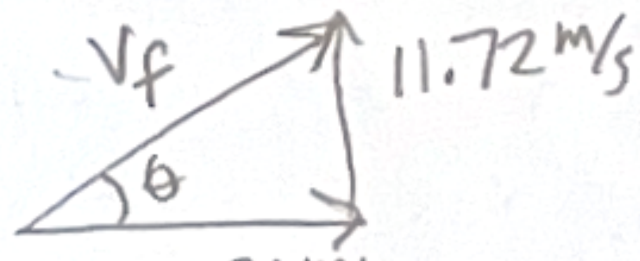
$32.31\,\frac{m}{s}\hat{i} + 11.72\,\frac{m}{s}\hat{j} = \vec{v}_f$

verify

$\vec{p}_i + \Sigma\vec{J} = \vec{p}_f$



Since the x-components are equal + the y-components are equal, both sides are the same!

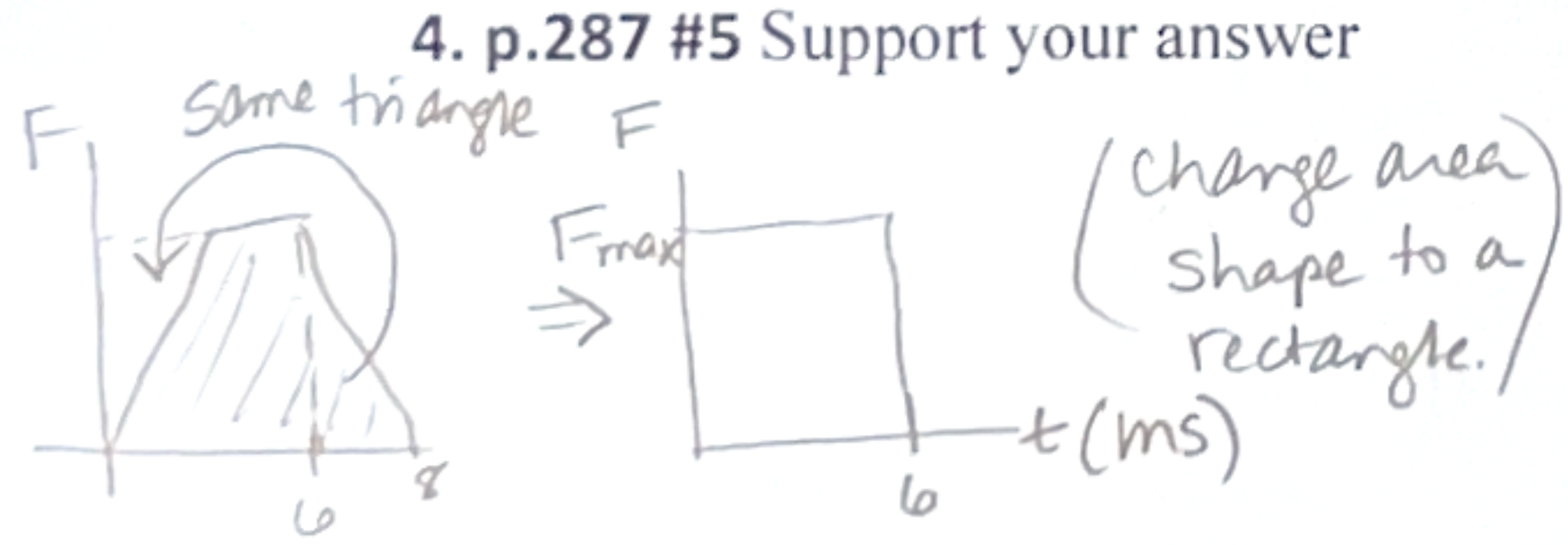


$v_f = \sqrt{(\ )^2 + (\ )^2}$
$v_f = 34.4\,m/s$

$\tan\theta = \frac{11.72\,m/s}{32.31\,m/s}$
$\theta = 20°$

$\boxed{\vec{v} = (34.4\,m/s, 20°\ N\ of\ E)}$

4. p.287 #5 Support your answer



(change area shape to a rectangle.)

Impulse = area of F vs. t graph
$6.0Ns = F_{max}(.006s)$

$\boxed{1000N = F_{max}}$