Big Exam #1

Imagine you jump <u>*horizontally*</u> (northward) off the side of a small boat by pushing with your legs. *This question is very much like Question #5 on PS #1.*

a) Describe as completely as possible what the boat does during this process. *I would use the momentum lens, because there is only an internal force of my legs. The outside force* $= \frac{\Delta p}{\Delta t} = 0$*, so the system momentum is conserved. I gain momentum in one direction, so the boat must gain an equal momentum in the opposite direction.*
   i) Make a drawing
   ii) What lens did you use?
   iii) Support the use of that lens
   iv) Apply the lens: What does the boat do?

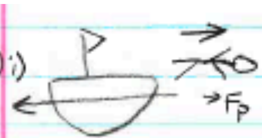
b) Let's say you have a mass of 50 kg, the boat has a mass of 150 kg and you have a velocity of 6 m/s, horizontally after you push off (lasting 0.3 s). What's the speed of the boat?
   i) What lens did you use?
   ii) Support the use of that lens
   iii) Apply the lens and find the speed

c) What was the average force from your legs on the boat?
   i) What lens did you use?
   ii) Support the use of the lens.
   iii) Apply the lens and find the force.

d) What was the average acceleration of the boat? ... follow the 3 steps in "c" above.

e) About how much work did I do in this process?... follow the 3 steps in "c" above. *As I described in class, there are several ways to solve this problem (as well as the other problems). I like an energy lens because the work I do with my legs is the change in kinetic energy of the Boat-Pete system.* $W = \Delta E = \Delta E_{Pete} + \Delta E_{Boat}$. We assume that very little energy is immediately lost to heat, so the work is just the kinetic energy of each of the two bodies. I get a total change in energy of 1200 J. Most students (as the one below) neglected to include the increase in kinetic energy of the boat.

a) i)

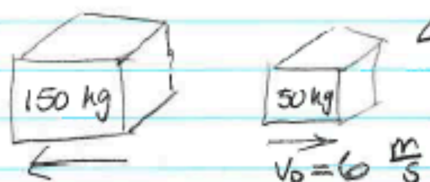


ii) Dynamics lense

iii) I used a dynamis lense because a force was exerted by Pete that caused acceleration for the boat and Pete in opposite directions. However, other lenses could be used to find more about the boat such as momentum since it will be constant to find the speed of the boat or kinematics to find the how long the boat moved for. why?

iv) Using purely the dynamics lense, the boat will ~~move~~ in the opposite direction of Pete. The accelerations will ~~not~~ equal for Pete and the boat, although the boat can be assumed heavier than Pete so the boat will have a slower speed, acceleration from rest, and distance moved. yes

b)



$\Delta t = 0.3$ s

$m_B = 3m_P$

i) Momentum lense

ii) Since we have the masses of the boat and Pete, as well as Pete's velocity, we can use $m_P v_P = m_B v_B$ to find the boat's speed. We can use the formula because momentum is constant since there is no outside force acting upon the interaction. Therefore $P_0 = 0$ and $P_F = 0$ so $P_B = P_P$ in opposite directions.

$\Delta p = F\Delta t$

A

iii) $m_P v_P = m_B v_B$

$$v_B = \frac{m_P v_P}{m_B} = \frac{50\ kg (6\ \frac{m}{s})}{150\ kg} = \boxed{2\ \frac{m}{s}}$$

dynamics $F \Rightarrow \Delta P$

c) i) ~~Kinematics~~ lense

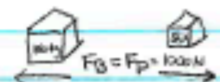
A/F

ii) Since we have both Pete's and the boat's velocity and mass, we can find the change of momentum for the boat. Therefore, we can use the formula $F = \frac{dp}{dt}$ to find the force of Pete's legs on the boat since we also know $dt = 0.3$ seconds. We know a force was needed to move the boat.

iii) $p_B = m_B v_B = 150\,kg(2\,\frac{m}{s}) = 300\,kg\,\frac{m}{s}$

$$F = \frac{dp}{dt} = \frac{300\,kg\,\frac{m}{s}}{0.3\,s} = \boxed{1000\,kg\,\frac{m}{s^2} \text{ or } 1000\,N}$$

d) i) Dynamics lense



ii) Now that we have the force from Pete's legs, we know that the boat had the same 1000 N acting on it in the opposite direction of Pete. Forces cause things to accelerate is a principle of dynamics so we can use the given mass and discovered force in F=ma to find the acceleration.

A

iii) Dynamics: F=ma

$$a_B = \frac{F_B}{m_B} = \frac{1000\,N}{150\,kg} = \frac{1000\,kg\,\frac{m}{s^2}}{150\,kg} = \boxed{6.67\,\frac{m}{s^2}}$$

e) i) Energy lense

ii) The energy lense must be used because we're looking for the amount of work Pete did in the process. Work is a key clue to use energy. Since the start velocity is 0, all the work will be kinetic energy so v is v_{fp} for final of Pete.

iii) $W_P = F_P \Delta X_P = K = \frac{1}{2} m_P v_{fP}^2 = \frac{1}{2}(50\,kg)(6\,\frac{m}{s})^2 = \frac{1}{2}(50\,kg)(36\,\frac{m^2}{s^2})$

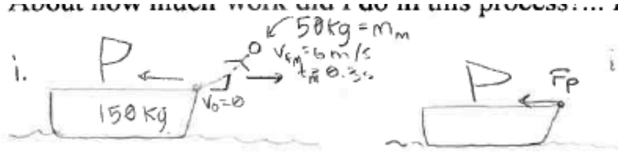
$$= 900\,kg\,\frac{m^2}{s^2} = \boxed{900\,J} + \Delta E_{Boat}$$

B

e) About how much work did I do in this process?... follow the 5 steps in "c" above.

m = me
p = push
b = boat

a.) i.



ii. Dynamics

iii. There is a force acting upon the boat from [illegible]

iv. The boat moves with equal momentum to your body in the opposite direction. ← why?

A/B

b) i. Momentum ii. Since we know there is no outside force acting on me and the boat we can use the equation $P_{fm} = P_{fb}$

iii. $p = mv$

$P_{fm} = 50kg(6m/s)$

$P_{m} = 300 kg\,m/s$

$P_{fm} = P_{fb} = 0 \rightarrow 300 kg\,m/s = 150 kg \times V_b$

$V_b = \frac{300 kg\,m/s}{150 kg} = 2 m/s$

A

c) i. Momentum ii. there is a force applied by my legs pushing off the boat causing a change in momentum

iii. $F = \frac{\Delta p}{\Delta t}$ $F_p = \frac{300 kg\,m/s}{0.3 s}$ $F_p = 1000 kg\,m/s^2 = 1000 N$

A

d) i. kinematics. ii. you are looking at acceleration, an explicit function of time

iii. $a = \frac{\Delta v}{\Delta t}$ $a_b = \frac{2 m/s}{0.3s} = 6.67 m/s^2$

A

e. i. Energy ii We are looking for the amount of work done by me when I push off the boat.

$W = F\Delta x$

$W = \Delta E$

$\Delta E = \frac{1}{2}mv^2$

$\Delta E_m = \frac{1}{2}(50kg)(6m/s)^2$

$\Delta E_m = 900 kg\,m^2/s^2 = 900 J = W_m$ + ΔE_{Boat}!

B

Your name ____