XF.16b **107**

PHYS-107(15) (Kaldon-) **Name** _____**S O L U T I O N**_____

WMU - Fall 2003

Final Exam - 200,000 points **CHECK-OUT:** ☐ T1 ☐ T2 ☐ Q23 ☐ _____

Rev. 12/07/03 Su.6

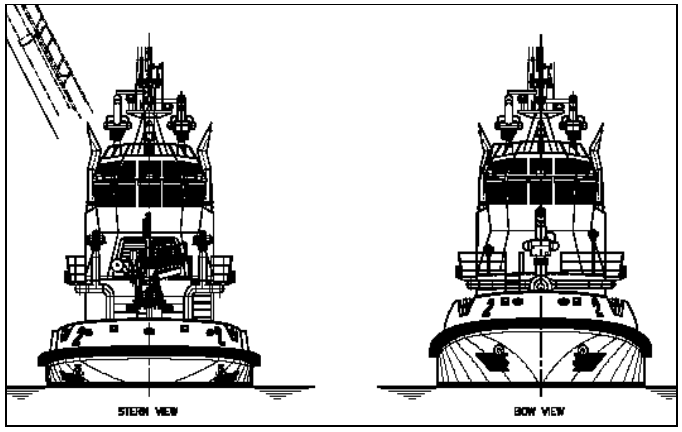
State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Short Answers Should Be Short! – Feel Free to Ask Any Questions

FINAL EXAM [FORM - B] NOON

PHYS-107 (KALDON-16)

FALL 2003

WMU



The New L.A.F.D. Fireboat 2 – Launched 2003

"Almost Over" (50,000 points) ***Multiple-Guess-Pick-The-Best-Answer-Fill-In-The-Bubbles***

1.) In parts (a)-(d), select which Newton's Law or Conservation Law best applies.

(a) Both cars get dented in a collision because of the forces in…
A = Newton's 1st B = Newton's 2nd C = Newton's 3rd
D = Momentum E = Energy F = None of these
Ⓐ Ⓑ **Ⓒ** Ⓓ Ⓔ Ⓕ

(b) Ballistic motion is also an example of…
A = Newton's 1st B = Newton's 2nd C = Newton's 3rd
D = Momentum E = Energy F = None of these
Ⓐ Ⓑ Ⓒ Ⓓ **Ⓔ** Ⓕ

(c) If there are no non-conservative forces doing work, then…
A = Newton's 1st B = Newton's 2nd C = Newton's 3rd
D = Momentum E = Energy F = None of these
Ⓐ Ⓑ Ⓒ Ⓓ **Ⓔ** Ⓕ

(d) A centripetal force shows up at the result of sum of forces equation when using…
A = Newton's 1st B = Newton's 2nd C = Newton's 3rd
D = Momentum E = Energy F = None of these
Ⓐ **Ⓑ** Ⓒ Ⓓ Ⓔ Ⓕ

In parts (e)-(h), select which speed best represents the situation described.

(e) *"Oh man, I have to run if I am going to make it to my Physics Final in time!"*
A = 1.5 m/s B = 6.0 m/s C = 25. m/s D = 250 m/s E = 340 m/s
F = 11,000 m/s
Ⓐ **Ⓑ** Ⓒ Ⓓ Ⓔ Ⓕ

(f) *"Did you hear that?"*
A = 1.5 m/s B = 6.0 m/s C = 25. m/s D = 250 m/s E = 340 m/s
F = 11,000 m/s
Ⓐ Ⓑ Ⓒ Ⓓ **Ⓔ** Ⓕ

(g) *"All I want to do after this test is get on a flight and fly south to where it's warm."*
A = 1.5 m/s B = 6.0 m/s C = 25. m/s D = 250 m/s E = 340 m/s
F = 11,000 m/s
Ⓐ Ⓑ Ⓒ **Ⓓ** Ⓔ Ⓕ

(h) *"Just strolling along watching the rain fall."*
A = 1.5 m/s B = 6.0 m/s C = 25. m/s D = 250 m/s E = 340 m/s
F = 11,000 m/s
Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ

Use vector $\vec{A}$ with an *x*-component $A_x = 27.0\ m$ and a *y*-component $A_y = -25.0\ m$ in the follow problems:

(i) The magnitude of this velocity vector is A = _____ .
A = 2.00 m B = 10.2 m C = 36.8 m
D = 52.0 m E = 104 m F = 1354 m
Ⓐ Ⓑ **Ⓒ** Ⓓ Ⓔ Ⓕ

(j) The Standard Angle for $\vec{A}$ is _____.
A = 42.8° B = 47.2° C = 132.8°
D = 137.2° E = 312.8° F = 317.2°
Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ **Ⓕ**

***"Fireboat 2 – See the Fire in the Port of Los Angeles." "Roger, copy."* (50,000 points)**

2.) On March 21, 2003, the world's most powerful dedicated fireboat was accepted for delivery by its Owner, the Los Angeles Fire Department, and began its delivery voyage from Freeland, Washington near Seattle to its home port of Los Angeles. The big monitor or water jet at the right of the photo shoots a stream of water out at a speed of 103 mph (46.1 m/s). In real life, including air resistance, the stream of water travels a horizontal range of 600 feet. Use the range equation or the kinematic equations and find the maximum distance *d* that any object with $v_0 = 46.1\ m/s$ can travel.

600 feet = 183.0 m

$$R = \frac{v_0^2 \sin 2\theta}{g} = \frac{(46.1 m/s)^2 (\sin(2\times 45°))}{9.81 m/s^2} = 216.6 m$$

$$v_y = v_{0y} - gt \ ; \ v_y = -v_{0y} \ ; \ v_{0y} = v_0 \sin 45°$$
$$-v_{0y} = v_{0y} - gt$$
$$-2v_{0y} = -gt$$
$$t = \frac{2v_{0y}}{g} = \frac{2(46.1 m/s)(\sin 45)}{9.81 m/s^2} = 6.646 \sec$$
$$d = v\,t \quad OR \quad x = x_0 + v_{0x}t + \tfrac{1}{2}a_x t^2$$
$$x = v_{0x}t = (v_0 \cos 45°)t$$
$$= (46.1 m/s)(\sin 45)(6.646 \sec) = 216.6 m$$

(b) The big monitor delivers water in an 8 inch (20.0 cm = 0.200 m) diameter stream with a force of 7500 lbs. (33,400 N). Using the definition of pressure, show that this is close to the 10 atmospheres in the design specifications. *1 atmosphere = 101,300 Pa.*

$$A = \pi r^2 \ ; \ D = 0.200m, \ r = \tfrac{D}{2} = 0.100m$$
$$P = \frac{F}{A} = \frac{33{,}400 N}{\pi (0.100m)^2} = 1{,}063{,}000 Pa$$

(c) Use Bernoulli's Equation and find the pressure P_1 needed to blow water out at $v_2 = 46.1\ m/s$. Use a pressure of $P_2 = 0$, so P_1 becomes a gauge pressure and can be compared to (b). *For fresh water,* $\rho_{water} = 1000\ kg/m^3$.

$$P_1 + \rho g h_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \tfrac{1}{2}\rho v_2^2$$
$$P_1 = \tfrac{1}{2}\rho v_2^2 = \tfrac{1}{2}(1000 kg/m^3)(46.1 m/s)^2$$
$$= 1{,}063{,}000 Pa$$

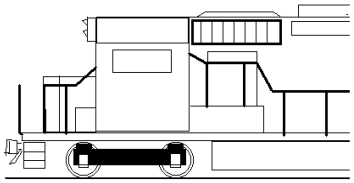
(d) The press release from the designers give the overall length as 105 feet (32.0 m), width as 29.0 feet (8.84 m) and depth below waterline as 13.3 feet (4.06 m). If the volume of the submerged part of the boat is 680. m^3, find the mass of water that is displaced by this boat in fresh water.

$$\rho = \frac{m}{V} \ ; \ m = \rho V$$
$$m = (1000 kg/m^3)(680. m^3) = 680{,}000 kg$$

(e) The main engines on LAFD #2 are V-12 MTU/Detroit Diesel Model 12V4000 diesel engines, each rated at 1,800 hp (1,343 kW). If the actual efficiency of this engine is 46.0% (0.460), then find the power wasted in Watts. *Remember that Actual Efficiency works for both Work & Energy (Joules) and Power (Watts).*

$$\varepsilon_{Actual} = \frac{W}{Q_H} = \frac{Useful\ Power}{Total\ Power}$$
$$Total\ Power = \frac{Useful\ Power}{\varepsilon_{Actual}} = \frac{1{,}343{,}000 W}{0.460}$$
$$= 2{,}920{,}000 W$$
$$Q_H = W + Q_C$$
$$Total\ Power = Useful\ Power + Waste\ Power$$
$$Waste\ Power = Total\ Power - Useful\ Power$$
$$= 2{,}920{,}000 W - 1{,}343{,}000 W = 1{,}577{,}000 W$$

Physics Train Wreck (50,000 points)



3.) A freight train is rolling through Kalamazoo MI at 100. mph (44.7 m/s). The locomotive and the five cars weigh 2,000,000 N. A pickup truck (mass = 1700 kg) has stalled on the track 100. meters in front of the train, on the railroad crossing. *Interesting information:* Train brakes use all the wheels of the train on all cars. Steel wheels on steel rail: $\mu_s = 0.74$ *and* $\mu_k = 0.57$.

(a) At a distance of 100. meters, the engineer applies the brakes, but they lock up the wheels and also blows the train's horn to warn the driver of the pickup truck. How long does it take for the sound to reach the pickup truck? *The speed of sound on this day at 0°C is 334 m/s.*

$$d = v\,t$$
$$t = \frac{d}{v} = \frac{100.m}{334m/s} = 0.2994\,\text{sec}$$

(b) If the horn has a resonant tube open at both ends of length L and the sound has a frequency of 400. Hz, find the length L if this wave is a fundamental.

$$v = f\lambda$$
$$\lambda = \frac{v}{f} = \frac{334m/s}{400Hz} = 0.8350m$$
$$\frac{\lambda}{2} = L = \frac{0.8350m}{2} = 0.4175m$$

(c) The train cannot come to a stop in 100. meters. Find the speed of the train just before it hits the truck. The braking force is equal to 0.57 × weight of the entire train.

$$F = \mu_s F_n = (0.57)(2{,}000{,}000N) = 1{,}140{,}000N$$
$$w = mg \;;\; m = \frac{w}{g} = \frac{2{,}000{,}000N}{9.81m/s^2} = 203{,}900kg$$
$$F = ma$$
$$a = \frac{F}{m} = \frac{-1{,}140{,}000N}{203{,}900kg} = -5.591m/s^2\,(=-\mu_s g)$$
$$v^2 = v_0^2 + 2a(x - x_0)$$
$$v = \sqrt{(44.7m/s)^2 + 2(-5.591m/s^2)(100.m)}$$
$$= 29.66m/s$$

OR

$$W = Fd = \Delta K.E. = \tfrac{1}{2}mv^2 - \tfrac{1}{2}mv_0^2$$
$$v^2 = v_0^2 + 2\frac{Fd}{m}$$
$$v = \sqrt{(44.7m/s)^2 + \frac{2(1{,}140{,}000N)(100.m)}{203{,}900kg}}$$
$$= 29.66m/s$$

(d) Suppose the train hits the truck, which is at rest. If the truck ends up riding on the front of the locomotive after the collision, what is the speed of the train and the truck? *If you didn't get an answer to (c), use* $v_{train} = 12.0$ *m/s.*

$$m_1v_1 + m_2v_2 = (m_1 + m_2)V$$
$$V = \frac{0 + m_2v_2}{(m_1 + m_2)}$$
$$= \frac{(203{,}900kg)(29.66m/s)}{(1700kg + 203{,}900kg)}$$
$$= 29.41m/s$$

(e) The train is so much bigger than the truck, it doesn't slow down much. If the collision takes place in just 150. milliseconds (0.150 seconds), then find the acceleration a and the force F needed to bring the truck from rest to the final speed of the wreck. *If you didn't get an answer to (d), use V = 12.0 m/s.*

$$a = \frac{\Delta v}{\Delta t} = \frac{29.41m/s - 0}{0.150\,\text{sec}} = 196.1m/s^2$$
$$F = ma = (1700kg)(196.1m/s^2) = 333{,}400N$$

Have Another Cup of Coffee (50,000 points)

4.) Jan needs coffee to stay awake while studying for her Physics final exam. Her electric hot plate generates 1200. W of heat when plugged into a 120. volt outlet. Find (a) the current *I* needed in the circuit and (b) the resistance *R* of the hot plate.

(a)
$$P = I\,V$$
$$I = \frac{P}{V} = \frac{1200.W}{120.volts} = 10.00A$$

(b)
$$V = I\,R$$
$$R = \frac{V}{I} = \frac{120.volts}{10.00A} = 12.00\Omega$$
$$P = \frac{V^2}{R}$$
$$R = \frac{V^2}{P} = \frac{(120.volts)^2}{(1200.W)} = 12.00\Omega$$

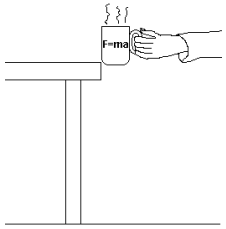
(c) Jan heats 0.500 liter of water (mass = 0.500 kg) in a pan. Ignoring the pan, how much energy *Q* does it take to heat the cold water from the faucet (50.0°F = 10.0°C) to boiling (212°F = 100.°C)? The specific heat of water is $c_{water} = 4180\ J/kg\cdot°C$,

$$Q = mc\Delta T = (0.500kg)\left(4180\ {}^{J}/_{kg\cdot°C}\right)(100°C - 10.0°C) = 188{,}100J$$

(d) At 1200. W, how long does it take for the hot plate to heat the water? *If you did not get an answer to (c), use Q = 400,000 J.*

$$P = \frac{W}{t}$$
$$t = \frac{W}{P} = \frac{188{,}100J}{1000.J/\sec} = 188.1\sec(= 3.135\min)$$

(e) Unfortunately, when Jan goes to set down her first cup of coffee, she misses the edge of the table and it falls 3.00 feet (0.914 m) to the floor. Find the speed of the coffee cup when it hits the floor.



$$v^2 = v_0^2 - 2g(y - y_0)$$
$$v = \sqrt{0 - 2(9.81m/s^2)(0 - 0.914m)} = -4.235m/s$$