PHYS-113(3) (Kaldon-10717)
WMU - Fall 2001
Exam 000 - 000,000 points
Sample Exam

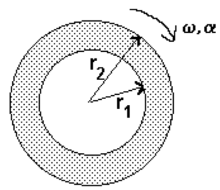
Name ____

Book Title _______*This is for Topic 1, not your textbook!*___
Section: **3a** (A to G) **3b** (H to M) **3c** (N to S) **3d** (T to Z) Rev. 10/28/01

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

Draggin´ Mah Pick ´Em Up Truck (25,000 points)

1.) A rear wheel drive pickup truck (m = 1808 kg) goes from zero to 60 mph (v_f = 26.8 m/s) in ten seconds flat (Δt = 10.00 s). (a) Each tire has a radius of 0.450 m. What are ω_0 and ω_f?



(b) Find α.

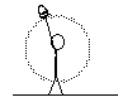
(c) Each tire has a mass of 17.0 kg, and the wheels that the tires are mounted on have a mass of 10.0 kg. Let the wheels be considered solid disks of radius r_1 = 0.300 m, and the tires to be thin hoops of radius r_2 = 0.450 m. Find the moment of inertia, I, of the two mounted tires on the rear axle. *Neglect the mass of the axle itself.*

(d) What is the torque, τ_{spin} , needed to accelerate the rear wheels?

(e) The force that moves the truck forward comes from friction as the wheel turns on the ground. Since this friction force is applied at a distance r_2 from the axle, the tires must be supplying this force as a torque. Find this torque, $\tau_{forward}$. Why don't τ_{spin} and $\tau_{forward}$ agree? What is the actual torque that the engine has to supply?

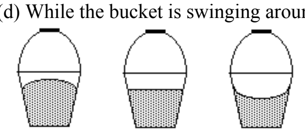
"Swing Your Bucket, Round and Round..." (25,000 points)

2.)(a) If you take a bucket of water, and swing around in an arc over your head, what must be the minimum speed, v, such that the water won't dump on your head? Take the length of your arm as 1.00 m.



If you start out holding the bucket by your side, you must reach this speed, v, in one-half revolution (otherwise the water dumps on your head). (b) What is the angular acceleration, α, required? (c) What is the torque, τ, required?

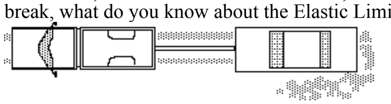
(d) While the bucket is swinging around, what do you think the surface of the water will do? Why?



(e) If the 30.0 cm high bucket is filled to the brim with water, and there is a small hole in the side 2.0 cm from the bottom, water will pour out the hole. If you drop the bucket, what is the speed of the water coming out of the hole while the bucket is in the air? Why?

"Tow, Tow, Tow Your Car, Gently Down The Street..." (25,000 points)

3.) Jim and Joe hook up a nylon cable and a hook from Jim's shiny new pickup onto the bumper of Joe's rusted old car (m = 2200 kg). The nylon cable is 3.00 m long and has a square cross-section (0.0100 m x 0.0100 m); the Young's Modulus for this nylon is 87×10^6 Pa. (a) Jim gets into the pickup and stretches the cable with a force of 10,000 N. Joe's car doesn't move, as it is stuck in the mud. If the cable stretches smoothly and does not break, what do you know about the Elastic Limit? ... the Tensile Strength?



(b) How far does the cable stretch?

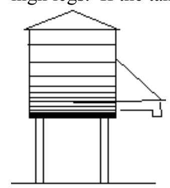
(c) If the nylon cable stretches linearly, it acts like a spring. Find the force constant "k" for this "spring".

(d) Find the potential energy stored in this "spring" and use conservation of energy to find the speed of the 1.00 kg hook when it suddenly comes loose from the bumper. *(This is why using tow ropes can be dangerous!)*

(e) Meanwhile Joe is still trying to get his car out of the mud. He decides to floor it and wheels just spin as if they were going forward at 40.0 m/s What is the rotational kinetic energy of the two back wheels? They are 0.900 m in diameter and have a mass of 30.0 kg each. Assume that they are solid.

"I'm A Water Tower, Tall and Stout, Here Is My Handle and Here Is My Spout..." (25,000 points)

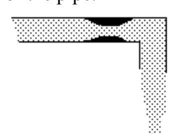
4.) An old-fashioned railroad water tower consists of a tank 4.00 m x 4.00 m x 4.00 m, sitting on 3.75 m high legs. If the tank is full, find the speed of water (a) that comes out of the spout...



(b) ... and when the water hits the ground.

(c) Why are the horizontal steel bands that are wrapped around the tank spaced closer together at the bottom and not at the top?

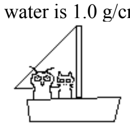
(d) The square pipe used in the spout has filled up with silt and rust from years of use, and so in the middle of the pipe, the opening is only half as wide and half as high as it is in the rest of the pipe. Completely describe the changes in the speed and pressure as the water goes through the constricted part of the pipe.



(e) If a stream of water were to pour out of the spout without gushing (i.e. no turbulent flow), the stream of water would "neck" (get thinner) as it headed down. Why?

"The Owl and the Pussycat Went To Sea In A Beautiful Pea Green Boat" (25,000 points)

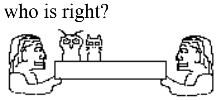
5.) The 9.0 kg Owl and the 7.0 kg Pussycat bought a 100.0 kg aluminum boat: 2.00 m long, 1.00 m wide, with sides 0.40 m high. (a) The density of aluminum is 2.7 g/cm^3 (2.7 x 10^3 kg/m^3) and the density of water is 1.0 g/cm^3 (1.0 x 10^3 kg/m^3) -- so why does the boat float?



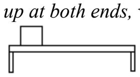
(b) Find the mass-to-volume ratio (the density) of the empty boat and the loaded boat.

(c) What is the volume of water displaced by the boat, when it is loaded with the Owl, the Pussycat and 100.0 kg of provisions?

(d) Along their travels, the Owl and the Pussycat have two large Gray Gorillas carry the boat and themselves a short distance from one sea to another. The two Gorillas stand there holding the loaded boat, one at each end, and begin to argue about which has the tougher job. "The Owl and the Pussycat and all their supplies are located only 0.30 m from my end. So I have to work harder than you do," said the First Gorilla. "Ah, but I am located farther from the center of mass than you and therefore I have the bigger torque. So I have to work harder than you do," replied the Second Gorilla. From a Physics point of view, who is right?

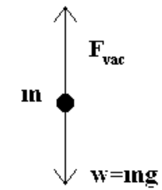


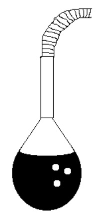
(e) Find the forces that each Gorilla has to apply to hold the boat. *Hint: Treat the boat like a board held up at both ends, with a block on it, as shown:*



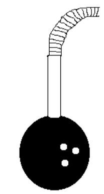
"Hi, I'm Dave Oreck and…" (50,000 points)

6.) "… my eight pound Oreck Hotel Vacuum is *so* powerful that it can pick up a sixteen pound bowling ball." That's what it says on the commercials – let's see how this is done. At the right is the Free Body Diagram of the bowling ball (m = 7.27 kg), being held in place by the force applied by the vacuum cleaner, F_{vac}. This is for the case where the vacuum cleaner applies *exactly* enough force to hold up the bowling ball. (a) Find F_{vac}.



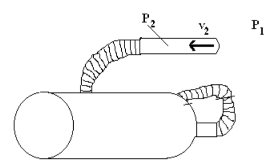


In the commercials, they put a funnel over the bowling ball. Let's find out why. A funnel with a large end 8 inches in diameter has an opening with an area, A = 0.0325 m². A typical vacuum cleaner hose is 2 inches in diameter, and has an opening sixteen times smaller, A = 0.00203 m². (b) Use the definition of Pressure to find the pressure being applied by the vacuum cleaner, P_{vac}, for both cases. *NOTE: You will have two answers here, one with and one without the funnel. If you didn't get an answer to (a), use F_{vac} = 80.0 N.*



(c) If the air pressure on the outside is P_1 = 102,400 Pa, then what is the pressure, P_2, *inside* the vacuum cleaner, for both cases? *If you didn't get answers to (b), use P_{vac} = 55,500 Pa and 105,500 Pa, for with and without the funnel respectively.*

(d) Take the pressure, P_2, for the case of *with* the funnel. If you just ran the vacuum cleaner without trying to hold up a bowling ball, then the air goes into the hose with a speed v_2. Find the speed of the air in the hose, v_2. *The density of air is ρ_{air} = 1.29 kg/m³. If you didn't get answers to (c), use P_2 = 55,500 Pa.*



(e) The vacuum cleaner hose is 1.75 m long. What are the wavelengths, λ, of the fundamental and first overtone that you might find from a standing wave in the hose?