Physics 110 – Third Hour Exam

Name:_____Answer Key__________________________________

Part I Short answers: Answer all questions with only one response in the margin.(3 pts each for a total of 30 pts). ***Note: for partial credit write a clear phrase or show calculations clearly justifying your choice***

_____C_______1. Calculating the lift force on an airplane comes from the Principle of
a. Continuity
b. Archimedes
c. Bernoulli
d. Superposition
e. None of the above

______E______2. A ladder is leaning against a wall with a man standing at its midpoint. Which of the following is a false statement?
a. The net vertical force on the ladder is zero.
b. The net horizontal force on the ladder is zero
c. The net torque about the bottom of the ladder is zero.
d. The net torque about the top of the ladder is zero
e. None of the above is false.

_______B_____3. In an Atwood machine (two unequal masses hung over a real pulley), the tension in the string attached to both masses is not the same because
a. the two masses are not the same
b. the pulley has a non-zero moment of inertia
c. there is friction in the pulley's bearings
d. the acceleration of the two masses is different
e. none of the above.

________A____4. The buoyant force on an immersed body has the same magnitude as
a. the weight of the fluid displaced by the body
b. the weight of the body
c. the difference between the weights of the body and the displaced fluid
d. the average pressure of the fluid times the surface area of the body
e. None of the above

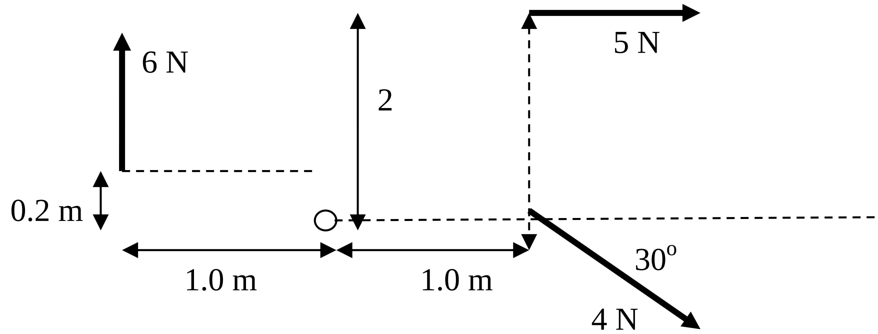
_______A_____5. Two hoses, one of 20-mm diameter, the other of 15-mm diameter, are connected one after the other to a faucet. At the open end of the hose, the flow rate of water is 10 liters per minute. Through which hose does the water flow faster?
a. the 15-mm hose
b. the 20-mm hose
c. the water velocity is the same in both cases
d. the answer depends on which of the two hoses comes first in the flow (ie. which is attached to the faucet.)

______B_______6. As a particle traveling in a circle slows down at a constant rate, its net acceleration
a) decreases and points less and less toward the tangential direction
b) decreases and points less and less toward the inward radial direction
c) increases and points more and more toward the outward radial direction
d) decreases and points more and more toward the inward radial direction
e) none of the above

______C______7. In a head-on collision between a seagull and a jet airplane
a) the momentum of the airplane is exactly conserved
b) the total kinetic energy is exactly conserved
c) the magnitude of the change in momentum of the seagull divided by the collision time equals the magnitude of the average force on the jet
d) the total momentum is zero
e) none of the above is true

______C______8. The highest dam in the world has a height of 335 m. When water is released from the bottom of the dam, what is its efflux velocity (in m/s)?
a) 40
b) 57
c) 81
d) none of the above

______B______9. The net torque exerted by the forces shown about point O is



a) 15 N-m
b) 18 N-m
c) 6 N-m
d) 14 N-m
e) None of the above

______D______10. Two point masses, each 5 kg, lie at either end of a light rod of length 2 m. What is the moment of inertia of the system about the left end of the rod (in kg-m^2)?
a) 10
b) 5
c) 40
d) 20
e) None of the above

Part II: **Problems:** Show all work for full credit. Point value for each part is shown.

1. A 5 m radius merry-go-round with a moment of inertia of 10,000 kgm^2 is rotating at 20 rad/min when the motor shuts off.
a) (8 pts) If the braking torque is 20 N-m, find the number of revolutions it turns through from when the motor shut off until it stops.

Torque = I α so $\alpha = 20/10000$
Then using $\omega^2 = \omega_o^2 + 2\alpha\, \Delta\theta$ we find $\theta = 27.8$ rad or 4.42 rev

b) (5 pts) If, while rotating at 20 rad/min, a person holding a 10 kg ball at the outer edge of the merry-go-round simply lets go of the ball, find the initial velocity of the ball when released (magnitude and direction, please).

$v = R\omega = 1.67$ m/s tangentially directed

c) (8 pts) For this part assume the axle of the merry-go-round is thoroughly greased and the braking torque is negligible. If the merry-go-round is initially rotating at 20 rad/min and ten 100 kg people simultaneous jump onto the outer edge of the merry-go-round, find its final angular velocity.

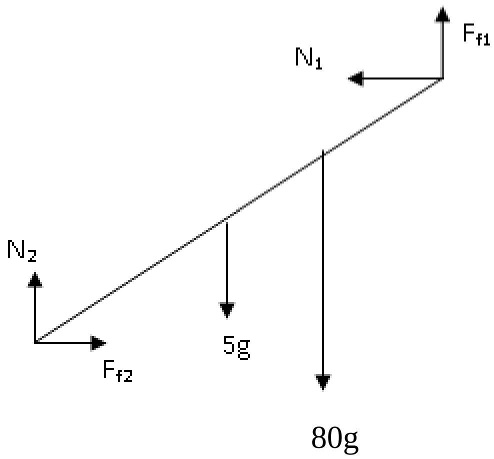
Conservation of angular momentum –

$$L_i = I\omega = 10000\ (20\text{rad/min}) = L_f = [10000 + 10(100)(5^2)]\omega_f$$

So $\omega_f = 5.71$ rad/min

2. A 4 m long 5 kg ladder leaning against a rough wall makes an angle of 60^o with the rough floor. An 80 kg man is standing 3/4 of the way up the ladder.

a) (7 pts) Draw a free-body diagram of the ladder showing all forces acting with appropriate labels.



b) Write down **equations** for the following, without solving, but substituting all known values for forces and distances into each equation:

i) (5 pts) the net torque about the bottom of the ladder

$5g(2 \cos 60) + 80g(3 \cos 60) – N_1(4 \sin 60) – F_{f1}(4 \cos 60) = 0$

ii) (3 pts) the net forces in the vertical direction

$5g + 80g – N_2 – F_{f1} = 0$

iii) (5 pts) the net torque about the top of the ladder

$80g(1 \cos 60) + 5g(2 \cos 60) – N_2(4 \cos 60) + F_{f2}(4 \sin 60) = 0$

3. A 6 m long piece of garden hose has a 1 cm inner diameter. Take the density of water to be 1000 kg/m^3.

a) (8 pts) If the hose is attached to a water faucet and turned on, it is found to take 10 seconds to fill a bucket holding 0.01 m^3. Find the velocity of the water in the hose.

$Q = 0.01\ m^3/10s = 0.001\ m^3/s$; but $Q = Av = (\pi r^2)v$; so $v = 0.001/(\pi(.005)^2) = 12.7$ m/s

b) (8 pts) The hose is old and has a bulge that increases the average diameter in one location to 2 cm. Find the change in local absolute pressure at the site of the bulge. Does it increase or decrease?

$P + 1/2\rho v^2$ = constant and Av = constant;

so

$P_1 + 1/2\ \rho v_1^2 = P_2 + 1/2\rho v_2^2$; but $v_2 = (A_1/A_2)v_1 = 3.2$ m/s;

So $P_2 - P_1 = \Delta P = ½\ \rho(v_1^2 - v_2^2) = ½\ (1000)(12.7^2 - 3.2^2) = 7.55 \times 10^4$ Pa increase

c) (5 pts) The bucket in part (a) is found to have a small hole at its bottom. Starting with the appropriate form of Bernoulli's equation, find the initial efflux velocity of the water if the height of the water in the bucket is initially 25 cm.

$½\ \rho v^2 + \rho gy$ = constant; so, $½\ \rho v^2 = \rho g\Delta y$ or $v^2 = 2g\Delta y$; or $v = 2.2$ m/s

d) (8 pts) A 0.5 kg frog jumps into the bucket of water. If the frog sinks, first find its *maximum* possible volume in cm^3 – Hint: the limiting condition is weight = buoyant force). Now, if the actual volume of the frog is 100 cm^3, find its apparent weight (ie., find the net downward force on the frog under the water.)

maximum volume if $\rho_{frog} = \rho_{water} = 1000$ kg/m^3; therefore

$\rho = 1000 = m/Volume = 0.5\ kg/V$; solving for V, $V = 5 \times 10^{-4}\ m^3 = 500\ cm^3$.

Also the effective weight = $mg - F_{buoyant} = 0.5(9.8) - \rho_{water}\ g\ (10^{-4}\ m^3) = 3.92$ N