Physics 150 Practice Final Exam

Problem	Points	Topic	Score
I	25	Quick Questions I	
II	25	Quick Questions II	
III	25	Dynamics	
IV	25	Work-Energy	
V	25	Momentum	
VI	25	Periodic Motion	
VII	25	Fluids	
VIII	25	Waves & Sound	
TOTAL			

- You may have two sheets of handwritten notes that are each ***one side*** of an $8\frac{1}{2}$" $\times$ 11" sheet of paper.
- Be sure to give units when it is relevant.
- To insure maximum credit you should solve each problem in formula form before "plugging in" numbers.
- The answer to the problems can be given in formula form or numerically as you prefer.
- If you choose to give the answer in formula form, be sure that the numerical values and units of the variables used are clearly stated. Correct formulas with incorrect "known" values will not earn full credit.
- Use the blank page facing the problem as scratch paper.
- Use well drawn pictures whenever they are relevant; they help you to think and the grader to understand your thinking.
- On the problem page show ***only*** the relevant formulas in the step-by-step logical order you used. Show all work.
- The important thing is to show that ***you know how to think***, not the final numerical result.
- If you are struggling with a problem, it will help your score to explain your thinking in words, even if you cannot get a complete answer. Partial credit will be given for partial solutions.
- As a general test-taking rule, you should ***never*** change an answer you have written unless you are ***absolutely certain*** that it is incorrect.

I. Quick Questions I

A. A golf ball is hit with an initial velocity of $v_0 = 33.0$ m/s at an angle of $\theta = 70°$ to the horizontal. To what height does the ball rise?

B. A force $\vec{\mathbf{F}} = (3\hat{\mathbf{i}} + 4\hat{\mathbf{j}} - 7\hat{\mathbf{k}})$ N is applied to a body at a point $\vec{\mathbf{r}} = (2\hat{\mathbf{i}} - 3\hat{\mathbf{j}})$ m. What is the torque about the origin produced on the body by the force $\vec{\mathbf{F}}$?

C. An asteroid has a moment of inertia of 3.00×10^{14} kg·m^2 and an angular momentum of 18.6×10^{10} kg·m^2/s. What is its rotational kinetic energy?

D. What is the oscillation period of a 0.350 kg mass swinging on a string of length 0.75 m?

E. A car with wheels of radius 25 cm is traveling down a dry road at 30 m/s. What is the radial acceleration of a point on the edge of the tire?

II. Quick Questions II

F. An open tube with fundamental frequency 100 Hz has a second overtone of the same frequency as the fundamental frequency of a certain stopped tube. The speed of sound is 344 m/s. What is the length of the stopped tube?

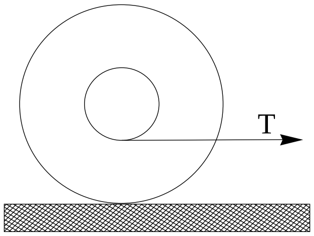
G. How long does it take a pulse to travel the length of a 9.00 m long string of mass 22.5 g under a tension of 16 N?

H. The Navy claims that the sound intensity level of a special underwater sonar signal is 250 dB. What is the power incident on an eardrum of area 10^{-4} m^2 in that signal?

I. A certain plastic will reduce in volume from 20 in^3 to 19 in^3 when subject to a pressure of 5×10^5 Pa. What is the bulk modulus of the plastic?

J. A planet with half the density of the earth has a radius three times that of the earth. What is the acceleration of gravity at the surface of this planet?

III. Dynamics



A string is wrapped several times around the hub of a spool as shown in the figure. The spool has mass $m = 2.00$ kg, a moment of inertia $I = 0.0200$ kg·m^2, and a radius of $R = 0.0300$ m. The hub has a radius of $r = 0.0100$ m. The string has a tension of 2.00 N. The spool rests rolls without slipping on a horizontal surface that has a coefficient of static friction $\mu_s = 0.8$.

(i) Draw a free-body diagram for the spool. Take the positive directions for the horizontal forces to the right and vertical forces upwards. Take the positive direction for torques to be clockwise.

(ii) Write an algebraic expression for the net torque on the spool about its center in terms of the string tension and other forces acting upon it and the dimensions of the spool.

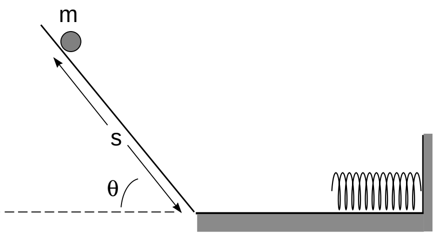
(iii) Write Newton's second law as applied to both the linear and rotational motion of the spool. (*Answer with two equations, one containing the acceleration, the other containing the angular acceleration.*)

(iv) What is the relationship between the angular acceleration of the spool about its center of mass and the acceleration of the center of mass?

(v) What is the acceleration of the spool?

$a =$ ____________________

IV. Work-Energy



A mass $m = 0.325$ kg is released from rest a distance $s = 2.00$ m up a plane inclined at $\theta = 27°$ to the horizontal. It then slides upon a frictionless floor until it contacts a massless spring, which compresses and then catapults it back the way it came and back up the inclined plane. The spring has a spring constant $k = 14.0$ N/m. Answer the following questions.

(i) If gravitational potential energy is taken to be zero at the floor, how much gravitational potential energy does the mass have initially?

$U_{\text{grav}} =$ ____________________

(ii) If there is no friction on the inclined plane, what is the speed of the mass when it reaches the floor?

$v =$ ____________________

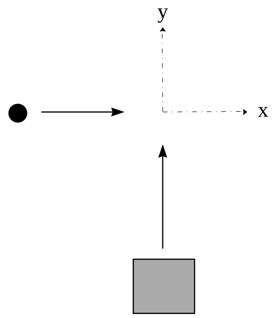
(iii) If there is no friction on the inclined plane, how far is the spring compressed?

$x =$ ____________________

(iv) If the mass were only to return a distance 1.5 m up the inclined plane, how much work would have to have been done by friction on the inclined plane?

$W_{\text{other}} =$ ____________________

V. Momentum and Collisions



A bullet of mass $m = 0.007\ kg$, moving with initial velocity $\mathbf{v}_b = 800\ \mathbf{i}\ m/s$, collides inelastically with a block of wood of mass $M = 2\ kg$, moving with initial velocity $\mathbf{v}_w = 1.5\ \mathbf{j}\ m/s$. The bullet becomes embedded in the wooden block. There are no external forces acting upon the bullet or wooden block.

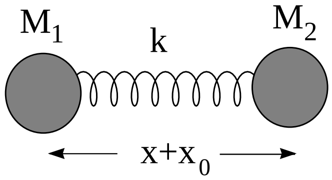
Find the final speed of the bullet/block object after the collision.

$v =$ ________________________

Find the direction in which the bullet/block object goes after the collision. Express your answer as the angle the final velocity makes with the x-axis.

$\theta =$ ________________________

VI. Periodic Motion



The separation, $x + x_0$, between the atoms in a diatomic molecule obeys the equation of motion

$$\frac{d^2x}{dt^2} = -\left(\frac{(M_1 + M_2)k}{M_1 M_2}\right) x \,,$$

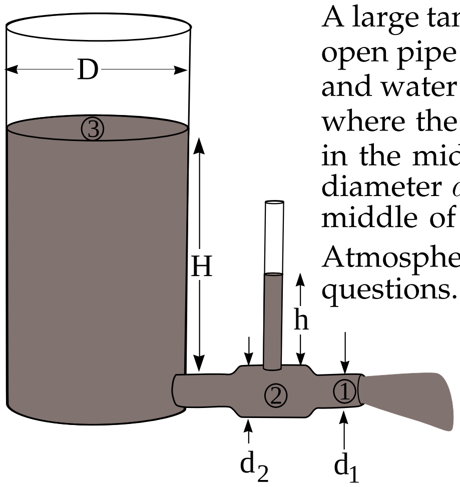
where x_0 is the equilibrium separation, M_1 and M_2 are the masses of the atoms, and $k = 181.6\,\mathrm{N/m}$ is the curvature of the potential energy function about equilibrium. For the purposes of this problem, k may be thought of as a spring constant. An oxygen molecule, O_2, has oxygen atoms of mass $M = M_1 = M_2 = 2.66 \times 10^{-26}\ kg$. The separation between the oxygen atoms, $x + x_0$, then obeys the equation of motion

$$\frac{d^2x}{dt^2} = -\left(\frac{2k}{M}\right) x \,.$$

From this information, find the period T of oscillation of the oxygen molecule.

$T =$ ____________________

VII. Fluids



A large tank of water, open at the top, is $D = 10.00$ m in diameter and has an open pipe in its side. The pipe is $H = 10.0$ m below the surface of the water and water is flowing quickly out of it. The pipe is $d_1 = 0.0500\ m$ in diameter where the water flows out of it and onto the ground. The pipe bulges out in the middle, where it is twice as thick as at the ends. The middle has a diameter $d_1 = 0.10$ m. There is a vertical tube of still water attached to the middle of the bulge in the pipe that is open to the atmosphere at the top. Atmospheric pressure at the time is 1.00×10^5 Pa. Answer the following questions.

(i) What are the pressures in the fluid at the top of the tank and at the opening of the pipe?

$p_3 =$ ____________________ $p_1 =$ ____________________

(ii) What is the speed of the water coming out of the pipe? (For the purposes of this question, you may regard the velocity of the water at the surface as essentially zero: $v_3 \simeq 0$.)

$v_1 =$ ____________________

(iii) How many cubic meters of water flow through the pipe per second?

$\Delta V/\Delta t =$ ____________________

(iv) What is the speed of the water at point 2 in the bulge?

$v_2 =$ ____________________

(v) What is the pressure at point 2 in the bulge and what is the height of the water in the vertical tube?

$p_2 =$ ____________________ $h =$ ____________________

(vi) Based on your answer above, calculate the speed with which the surface of the water is falling. Is it negligible?

$v_1 =$ ____________________

VIII. Waves & Sound

Standing waves on a string 3.00 m long are described by the function

$$y(x,t) = (1.24\ \mathrm{mm})\ \sin\left[2\pi\left(\frac{x}{0.300\ \mathrm{m}}\right)\right]\ \cos\left[2\pi\left(\frac{t}{0.00200\ s}\right)\right]. \tag{1}$$

The string is fixed at both ends, one of which is at $x = 0$. Answer the following questions.

(i) What is the wavelength of the standing wave described in Eq. (1)?

$\lambda =$ ________________

(ii) What is the amplitude of the standing wave described in Eq. (1)?

$A =$ ________________

(iii) What is the frequency of the standing wave described in Eq. (1)?

$f =$ ________________

(iv) What is the speed of the standing wave described in Eq. (1)?

$v =$ ________________

(v) What mode of the string does this standing wave describe?

$n =$ ________________

(vi) What is the maximum transverse velocity of a particle in the string?

$v_{\mathrm{max}} =$ ________________