

# Physics 303 Hour Exam II

Name: \_\_\_\_\_

November 10, 1999

Problem	Points	Topic	Score
I	20	Quick Questions	
II	20	Equilibrium	
III	20	Work-Energy	
IV	20	Momentum, Impulse, & Collisions	
V	20	Rotational Dynamics	
TOTAL			

- 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.
- 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 grade to explain your thinking in words, even if you cannot get a complete answer. Partial credit will be given for partial solutions.

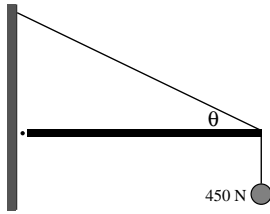
## *I. Quick Questions*

A. It takes  $10\text{ J}$  of work to compress a certain spring  $10\text{ cm}$ . How much work will it take to compress that spring  $30\text{ cm}$ ?

B. Two nickel metal asteroids, one of mass  $4 \times 10^{10}\text{ kg}$  and the other of mass  $2 \times 10^{10}\text{ kg}$  collide head on and stick together. Initially the heavier asteroid has a velocity of  $10\mathbf{i}\text{ m/s}$  while the smaller has a velocity of  $-2\mathbf{i}\text{ m/s}$ . What is the final velocity of the combined asteroid?

C. A disk of radius  $r = 1\text{ cm}$  rolls  $62.8\text{ cm}$  down a plane inclined at  $30^\circ$  to the horizontal. If the disk rolls without slipping, how many revolutions did it make?

## II. Equilibrium



A light weighing  $450\text{ N}$  is hung from the end of a beam that weighs  $300\text{ N}$ . The beam is connected to the wall by a hinge at one end and a lightweight cable at its other. The cable makes an angle of  $\theta = 35^\circ$  with the beam. The center of gravity of the horizontal beam is at its center. Denote the length of the beam by  $L$ .

(i.) Draw a free body diagram for the beam. Include, and clearly label, all forces acting.

(ii.) Write down the conditions for equilibrium as applied to this problem. Take the  $y$ -axis positive upwards and the  $x$ -axis positive to the right and torques positive in the counter-clockwise sense.

(iii.) Find the tension in the cable.

$$T = \underline{\hspace{10em}}$$

(iv.) Find the vertical and horizontal components of the force exerted on the beam at the hinge on the wall.

$$R_x = \underline{\hspace{10em}}$$

$$R_y = \underline{\hspace{10em}}$$

### III. Work-Energy

Tarzan grabs a vine hanging from a tall tree when he is running at  $10 \text{ m/s}$ . How high can he swing upward? (Ignore friction and air resistance.)

$$h = \underline{\hspace{10em}}$$

If Tarzan has a mass of  $m = 80.0 \text{ kg}$  and his maximum height when swinging on the vine is actually  $0.800 \text{ m}$  less than you calculate above, find the amount of work done on Tarzan by air resistance and other non-conservative forces.

$$W_{\text{nc}} = \underline{\hspace{10em}}$$

#### *IV. Momentum, Impulse, Collisions, & Center of Mass*

An astronaut of mass  $m = 70 \text{ kg}$  is out spacewalking in an empty part of the galaxy when she notices that she is out of fuel for her jetpack. Just then, she is at rest relative to her spacecraft and is dismayed to see that she is at the end of the tether (rope) of length  $\ell = 10 \text{ m}$  and negligible mass that attaches her to her spacecraft (of mass  $M = 6930 \text{ kg}$ ). The astronaut pulls herself to her spacecraft by pulling on the tether. If by pulling on the tether she gives herself a speed of  $2 \text{ m/s}$ , what speed does she impart to her spacecraft?

$$v_{\text{spacecraft}} = \underline{\hspace{10em}}$$

Given that the astronaut and her ship meet at their center of mass, how far has her spacecraft moved from its original position when she reaches it?

$$x = \underline{\hspace{10em}}$$

## V. Rotational Dynamics

A car wheel has a moment of inertia of  $2 \text{ kg m}^2$ , a mass of  $20 \text{ kg}$ , and a radius of  $0.35 \text{ m}$ . When the car has a speed of  $55 \text{ mph} \approx 24 \text{ m/s}$ , what is the angular speed of the wheel?

$$\omega = \underline{\hspace{10em}}$$

What is the total kinetic energy of the wheel?

$$KE^{\text{total}} = \underline{\hspace{10em}}$$

Suppose that the car has an acceleration  $a = 3 \text{ m/s}^2$  at the instant that its speed is  $24 \text{ m/s}$ . What is angular acceleration of the wheel?

$$\alpha = \underline{\hspace{10em}}$$

What total torque on the wheel will produce this angular acceleration?

$$\tau = \underline{\hspace{10em}}$$