

Physics 150 Practice Exam II

You will have one hour to complete this exam. There are two sections to this exam.

Section I: The first section is a set of twelve multiple choice or short answer questions. Each question is worth five points. Write your answers carefully in the blanks in front of the questions. If a letter is written and an answer is circled, the written letter will be the answer graded. No partial credit is given in this section. The maximum number of points you can earn in this section is 50 points, so if you miss one or two questions, you will still earn full credit.

Section II: The second section of the exam consists of three (3) problems, of which you are to complete two (2). Each of these problems is worth 25 points, for a total of 50 points. You must indicate clearly which one of the problems you are **not** answering in this section, for example by leaving it blank or by crossing it out if you've started to work it but changed your mind. If you do not indicate which problem you are not doing, two will be graded at random.

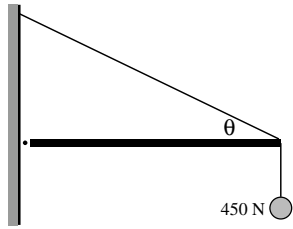
Section	Max Points	Score
I	50	
II	50	
TOTAL		

- You may have a sheet of your own handwritten notes that is **one side** of an $8\frac{1}{2}'' \times 11''$ sheet of paper.
- You may use a calculator, though you may not share one with someone else in the class. Make sure that your batteries are fresh. **Use of a smartphone calculator app is not allowed.**
- You should be sure to give units when it is relevant.
- You should be sure to use the correct number of significant figures.
- You should solve each problem in formula form before “plugging in” numbers to ensure maximum credit.
- You should show **only** the relevant mathematics in the correct step-by-step logical order on the problem pages in Section II. You should show all work. Correct numerical answers with incorrect reasoning will not earn full credit.
- The answers to the problems in Section II may be given in formula form or numerically as you prefer. All known or given quantities must be given clearly, with proper units.
- You should use well drawn pictures whenever they are relevant; they help you to think and the grader to understand your thinking.
- If you are struggling with a problem in Section II, 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.
- If you run low on time on the multiple choice section, it will help your grade to eliminate obviously incorrect answers and then make an educated guess. Do not leave any multiple choice questions unanswered.
- As a general test-taking rule, you should **never** change an answer you have written unless you are **absolutely certain** that it is incorrect.

- _____ 1. An engine has a torque of $200 \text{ N}\cdot\text{m}$ at 6000 rpm . Its power output is
- (A) less than 50 kW .
 - (B) at least 50 kW but less than 150 kW .
 - (C) at least 150 kW but less than 200 kW .
 - (D) 200 kW or greater.
- _____ 2. 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 $10 \hat{i} \text{ m/s}$ while the smaller has a velocity of $-2 \hat{i} \text{ m/s}$. What is the final speed of the combined asteroid?
- (F) less than 2 m/s .
 - (G) at least 2 m/s but less than 5 m/s .
 - (H) at least 5 m/s but less than 8 m/s .
 - (I) 8 m/s or greater.
- _____ 3. A disk of radius $r = 1 \text{ cm}$ rolls 62.8 cm down a plane inclined at 30° to the horizontal. If the disk rolls without slipping, how many revolutions does it make?
- (J) 2 revolutions or less.
 - (K) at least 2 revolutions but less than 5 revolutions.
 - (L) at least 5 revolutions but less than 8 revolutions.
 - (M) 8 revolutions or greater.
- _____ 4. An L-shaped object has two uniform, perpendicular arms, each 6 m long, that lie along the positive x -axis and along the y -axis respectively, with the bend at the origin. The center of mass $(x_{\text{CM}}, y_{\text{CM}})$ of the whole object is at
- (N) the origin.
 - (O) $(1.5 \text{ m}, 1.5 \text{ m})$
 - (P) $(3 \text{ m}, 3 \text{ m})$
 - (E) $(6 \text{ m}, 6 \text{ m})$
- _____ 5. A particle moving along the x -axis has a potential energy $V(x) = x(x - 2)$. When the particle is at $x = 2$, it feels a force that
- (Q) gives a stable equilibrium at $x = 2$.
 - (R) is toward the positive x -direction
 - (S) is toward the negative x -direction
 - (U) gives an unstable equilibrium at $x = 2$.
- _____ 6. An electric car can store 100 kWh of energy in its battery. How much mass needs to be converted to energy to obtain 100 kWh ?
- (T) less than a picogram.
 - (W) at least a picogram but less than a nanogram.
 - (X) at least a nanogram but less than a milligram.
 - (Z) a milligram or greater.

- _____ 7. In a collision of two billiard balls that bounce off of each other, the total momentum is the same before and afterwards, but the total kinetic energy of the billiard balls is less after the collision by 5%. The collision is
- (Z) elastic.
 - (Y) completely inelastic.
 - (W) inelastic.
 - (E) completely elastic.
- _____ 8. A steel wire with a 200 GPa Young's modulus and a 10^{-3} cm^2 cross-sectional area is subject to a 2000 N tension. The tensile stress in the wire is
- (U) less than 1 MPa.
 - (S) at least 1 MPa but less than 100 MPa.
 - (R) at least 100 MPa but less than 10 GPa.
 - (Q) 10 GPa or greater.
- _____ 9. A string moves without slipping on a pulley of radius 2.0 cm. The string has a tension of 10 N on one side and a tension of 15 N on the other. The pulley is frictionless but has a moment of inertia of $0.002 \text{ kg}\cdot\text{m}^2$. The angular acceleration of the pulley is
- (P) less than $100 \text{ rad}/\text{sec}^2$.
 - (O) at least $100 \text{ rad}/\text{sec}^2$ but less than $200 \text{ rad}/\text{sec}^2$.
 - (N) at least $200 \text{ rad}/\text{sec}^2$ but less than $300 \text{ rad}/\text{sec}^2$.
 - (T) $300 \text{ rad}/\text{sec}^2$ or greater.
- _____ 10. A spherical neutron star of radius 10 km spinning around its axis at 1000 revolutions per second suffers a "glitch" in which the crust collapses inward uniformly and its radius decreases by 1 cm. Its angular velocity increases by
- (M) less than 0.1 rev/sec.
 - (L) at least 0.1 rev/sec but less than 1 rev/sec.
 - (K) at least 1 rev/sec but less than 10 rev/sec.
 - (J) 10 rev/sec or greater.
- _____ 11. Each second, 120 cm^3 of fluid flows through a pipe of cross-sectional area 2.00 cm^2 . The speed of the fluid in the pipe is
- (H) less than 10 cm/sec.
 - (G) at least 10 cm/sec but less than 50 cm/sec.
 - (F) at least 50 cm/sec but less than 100 cm/sec.
 - (X) 100 cm/sec or greater.
- _____ 12. The gauge pressure at the bottom of a beaker of water 12 cm deep is
- (D) less than 800 Pa.
 - (C) at least 800 Pa but less than 1600 Pa.
 - (B) at least 1600 Pa but less than 3200 Pa.
 - (A) 3200 Pa or greater.

Problem 1: Equilibrium



A light weighing 450 N is hung from the end of a uniform beam that weighs 300 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 . **Take the y-axis positive upwards and the x-axis positive to the right and torques positive in the counter-clockwise sense.**

- (1.) Draw a free body diagram for the beam. Include, and clearly label, all forces acting.
- (2.) In terms of the tension in the lightweight cable, T , find, or show how to find, the torque that the tension T exerts on the beam, **calculated about the hinge?**

$$\tau_{\text{tension}} = \underline{\hspace{10cm}}$$

- (3.) What torque is exerted on the beam by forces at the hinge, **calculated about the hinge? Explain.**

$$\tau_{\text{hinge}} = \underline{\hspace{10cm}}$$

- (4.) Find, or show how to find, the tension in the cable.

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

- (5.) Find, or show how to find, the vertical and horizontal components of the force exerted on the beam at the hinge on the wall.

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

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

Problem 2: Momentum, Impulse, Collisions, & Center of Mass

An astronaut of mass $m = 70$ kg is out spacewalking in an empty part of the galaxy when she notices that she is out of fuel for her rocketpack. 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 $\ell = 10$ m and negligible mass that attaches her to her spacecraft (of mass $M = 6930$ kg). The astronaut pulls herself to her spacecraft by pulling on the tether.

- (1.) If by pulling on the tether she gives herself a speed of 2 m/s, what is the magnitude of her momentum?

$$p_{\text{astronaut}} = \underline{\hspace{10em}}$$

- (2.) If by pulling on the tether she gives herself a speed of 2 m/s, what speed does she impart to her spacecraft?

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

- (3.) If while pulling on the tether, the astronaut's rate of change of momentum is 0.013 kg m/s², what is the rate of change of the momentum of her spacecraft?

$$\left. \frac{dp}{dt} \right|_{\text{spacecraft}} = \underline{\hspace{10em}}$$

- (4.) If while pulling on the tether she gives herself an acceleration of 0.02 m/s², what acceleration does she impart to her spacecraft?

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

- (5.) How far has her spacecraft moved from its original position when she reaches it?

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

Problem 3: Rotational Dynamics

A 20-kg car wheel has a moment of inertia of $2.10 \text{ kg}\cdot\text{m}^2$, and a radius of 0.350 m.

- (1.) When the car has a speed of $24 \text{ m/s} \approx 55 \text{ mph}$, find, or show how to find, the angular speed of the wheel.

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

- (2.) When the car has a speed of $24 \text{ m/s} \approx 55 \text{ mph}$, find, or show how to find, the angular momentum of the wheel.

$$L = \underline{\hspace{10cm}}$$

- (3.) When the car has a speed of $24 \text{ m/s} \approx 55 \text{ mph}$, find, or show how to find, the **total** kinetic energy of the wheel.

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

- (4.) If the car has an acceleration $a = 3.0 \text{ m/s}^2$ at the instant that its speed is 24 m/s , find, or show how to find, the angular acceleration of the wheel.

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

- (5.) Find, or show how to find, the total torque on the wheel will produce this angular acceleration.

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