Name: _____

PHYS 1210-02 Exam 4

Standards 46–56

Calculators of any type are permitted. You may bring your own 8 ½" × 11"notes sheet, which may contain information on both sides, and a pine cone. Each question is worth one point unless otherwise indicated.

Enter your answer to a free response question inside the box provided for the question. Include units with all quantitative answers. Do not make stray marks in the box, and do not write your answer outside the box. **Answers written outside the box will not be credited**. Show your work in the space provided with the question. It is a good idea to write your answers in pencil.

If the question asks for a single selection from provided options, **fill** the circle (○) by the most correct answer. If the question asks you to select all appropriate options, **fill** the squares (☐) by all correct options. Do not check, mark an "X," circle, or otherwise indicate your choices. To revoke a choice, fully erase the mark.

Questions

1. (10 points) A uniform copper sphere and a uniform aluminum sphere have the same mass. The density of aluminum is 2700 kg/m^3, and the density of copper is 8960 kg/m^3.

   What is the ratio of the radius $r_{\mathrm{Al}}/r_{\mathrm{Cu}}$ of the aluminum sphere to the radius of the copper sphere? ☐

2. In a car's hydraulic braking system, the cylinder driving a brake pad has a cross-sectional area of 12.0 square centimeters.

   A. (10 points) When the driver pushes forcefully on the brake pedal, the brake pad presses against the disk with a force of 1450 newtons. What is the minimum gauge pressure of the hydraulic fluid in the cylinder? ☐

B. (10 points) When the driver presses on the brake pedal, the brake lever pushes on its own cylinder, which has a cross-sectional area of 0.500 square centimeters. That cylinder is connected by tubing to the cylinder driving the brake pad. What is the minimum gauge pressure in the brake lever's cylinder when the brake pad presses against the disk?

3. (10 points) The lower end of a long plastic straw is immersed below the surface of the water in a cup. A person sucking on the upper end of the straw can pull water into the straw to a vertical height of 1.10 meters above the surface of the water in the cup. The absolute atmospheric pressure at the cup is 79,945 pascals. What is the pressure at the top of the water column inside the straw?

4. Polypropylene is a commodity thermoplastic with a density of 855.0 kg/m^3. When a block of polypropylene with a volume of 2.00×10^{-3} m^3 floats on water, what volume of the block is above the waterline?

5. Water flows in a pipe with a varying cross-sectional area, and at all points the water completely fills the pipe. At one elevation, the cross-sectional area of the pipe is 7.00×10^{-4} m^2, the pressure is 150,000 Pa, and the water flows with a speed of 1.50 m/s. At a point that is 0.500 meters lower than the first, the pressure is the same, 150,000 Pa.

   A. (7 points) What is the speed of the water at the lower point?

   B. (3 points) What is the cross-sectional area of the pipe at the lower point?

6. The planet Venus and the planet Earth both orbit the Sun. The mass of Venus is $m_V = 4.87 \times 10^{24}$ kilograms, the mass of Earth is $m_E = 5.97 \times 10^{24}$ kilograms, and the mass of the Sun is $m_S = 1.99 \times 10^{30}$ kilograms. Their orbits are nearly circular. Venus's average distance from the Sun is $r_V = 1.08 \times 10^{11}$ m, and Earth's average distance from the Sun is $r_E = 1.50 \times 10^{11}$ m. Gravitational constant $G = 6.6743 \times 10^{-11}$ m^3/(kg·s^2).

   A. (10 points) What is the ratio of Earth's gravitational attraction to the Sun to Venus's gravitational attraction to the Sun? In other words, if F_V is Venus's gravitational attraction to the Sun and F_E is Earth's gravitational attraction to the Sun, find a such that $F_E = aF_V$.

B. (10 points) What is the ratio of Earth's gravitational potential energy in its orbit to Venus's gravitational potential energy in its orbit? In other words, if U_V is Venus's gravitational potential energy and U_E is Earth's gravitational potential energy, find a such that $U_E = aU_V$.

C. (5 points) If a 1400-kilogram satellite were to orbit Venus in a circular orbit with a period of 240 minutes, what would be the radius of its orbit?

D. (3 points) What would be the satellite's kinetic energy be in its 240-minute orbit?

E. (2 points) If the satellite were to adopt a new circular orbit with a period of 480 minutes (twice its previous period), would its kinetic energy be greater or less?

- ○ a. Its kinetic energy would be greater in the 480-minute orbit.
- ○ b. Its kinetic energy would be less in the 480-minute orbit.
- ○ c. Its kinetic energy would not change.
- ○ d. It depends.

7. A spherical shell of radius *R* has total mass *M*.

   A. (5 points) At a distance r_1 from the center of the shell, where $r_1 > R$, what is the formula for the gravitational field due to the sphere? Express in terms of *M*, *R*, r_1, and any necessary physical constants.

   B. (5 points) At a distance r_2 from the center of the shell, where $r_2 < R$, what is the formula for the gravitational field due to the sphere? Express in terms of *M*, *R*, r_2, and any necessary physical constants.

8. (10 points) Kepler's equal-area law of planetary motion states that when a body orbits the Sun in an elliptical orbit, the line segment from the Sun to the body sweeps out area at a constant rate at all points and all times in its orbit. What fundamental principle of physics is responsible for this property?