General Physics I–Honors: PHYS 101H (Fall 2023)
Quiz 8–solutions

Chris Monahan
William & Mary

Instructions

In this quiz you will apply your understanding of Noether's theorem, pressure and density. Read the following instructions carefully.

DO NOT TURN OVER THIS SHEET UNTIL INSTRUCTED.

Please write your name on the quiz.

You have ten minutes to attempt all three questions in this quiz.

You may use electronic calculators.

You may **not** use:

- any formula sheets or notes;
- electronic devices, including phones, tablets and laptops (unless previously arranged);
- textbooks or other reference resources;
- course notes or slides.

Question 1 **3pts**

State Noether's theorem in words, using full sentences, and provide one expample of its application.

Solution 1

Noether's theorem states that for every continuous symmetry, there is a corresponding conserved physical quantity. Examples of Noether's theorem include conservation of momentum arising from translational symmetry, conservation of energy arising from time translational symmetry, and conservation of angular momentum arising from rotational symmetry.

Question 2 **3pts**

A spring, with spring constant $k = 15$ N/m, is compressed by 0.3 cm from its equilibrium position and used to hold a small pin, with cross-sectional area 10 mm^2, in place. What is the pressure exerted on the pin by the spring? Assume that the spring exerts a force uniformly over, and perpendicular to, the cross-sectional area of the pin.

Solution 2

The magnitude of the force exerted by the spring is

$$F = kx = 15 \cdot 0.003 = 0.045\,\mathrm{N}.$$

The pressure that this exerts is given by

$$P = \frac{F}{A} = \frac{0.045}{10/10^6} = \boxed{4500\,\mathrm{Pa}}.$$

Question 3 **4pts**

Calculate the buoyant force on a cube of side length $a = 1$ cm that is exactly half submerged (that is, the fluid level reaches halfway up the vertical faces of the cube) in:

(a) water (take the density of water to be 1000 kg/m^3);

(b) mercury (take the density of mercury to be 13,500 kg/m^3).

Solution 3

In both cases, the buoyant force is given by the weight of the fluid displaced. The volume of fluid displaced is $V = 0.5$ cm^3. Thus

(a)

$$F_B = \rho_W V g = 1000 \cdot \frac{0.5}{10^6} \cdot 9.81 = \boxed{0.0049\,\mathrm{N}}$$

(b)

$$F_B = \rho_M V g = 13500 \cdot \frac{0.5}{10^6} \cdot 9.81 = \boxed{0.066\,\mathrm{N}}$$