Physics 2305 19 April, 2000
Practice for Exam 3

Exam 3 will consist of 8 multiple choice questions (4 worth 8 points each and 4 harder ones worth 10 points each) and 2 free-form questions (worth 14 points each).

Instructions: Use only the equation sheet (or study guide), a calculator, and a pen or pencil. Timing yourself makes a big difference on how difficult this practice test seems; give yourself no more than 60 minutes. When you're done, use the key at the end to grade yourself.

1. A liquid in a piston has a density of 640 kg/m^3. The top of the piston has an area of 0.16 m^2, and it is pressed downward into the liquid with a force of 36 N. What is the gauge pressure 10 cm below the piston?

A) 230 Pa
B) 630 Pa
C) 660 Pa
D) 850 Pa

2. Oberon is the outermost of the five large moons of Uranus. Its radius is 1550 km. If the escape velocity from its surface is 1.42 km/s, what is its average density?

A) 870 kg/m^3
B) 1100 kg/m^3
C) 1500 kg/m^3
D) 2100 kg/m^3

3. A physical pendulum consists of a metal plate of diameter (D) 25 cm rotating about an axis perpendicular to its surface, but at the edge instead of through its center. It has a moment of inertia = (3/8) $M D^2$. What is its period of oscillation on the surface of the Earth?

A) 0.61 s
B) 0.82 s
C) 0.87 s
D) 1.00 s

4. The center of the Milky Way Galaxy contains a massive black hole with a mass equal to roughly one million solar masses. What is the distance from the center to the event horizon?

A) 1.5×10^9 m
B) 3.0×10^9 m
C) 4.4×10^{12} m
D) 8.9×10^{12} m

5. A pipe containing water (ρ = 1000 kg/m^3) narrows from a cross section of 4.0 cm^2 to 2.0 cm^2 while dropping a vertical distance of 1.0 m. The velocity of the water in the wide section is 1.0 m/s. What is the difference in pressure between the wide and narrow sections?

A) 8.3 kPa
B) 9.8 kPa
C) 150 kPa
D) 180 kPa

6. A simple pendulum has a period of 1.000 seconds on the surface of the Earth (R=6370 km). What is the period of the pendulum in an airplane at an altitude of 20,000 m?

A) 0.997 s
B) 0.998 s
C) 1.002 s
D) 1.003 s

7. A sample of 1.0 kg of steam at an initial temperature of 100°C is condensed into water and cooled. A total of 2900 kJ of energy is removed from the sample in the process. What is the final configuration of the sample?

Spec. heat of ice	2.22 kJ kg^{-1} K^{-1}	of water	4.19 kJ kg^{-1} K^{-1}
Heat of fusion	333 kJ kg^{-1}	of vaporization	2256 kJ kg^{-1}

A) all at 100°C, some water, some steam
B) all liquid, temperature between 0°C and 100°C
C) all at 0°C, some water, some ice
D) all frozen, temperature less than 0°C

8. A room is heated to 68 °F (20 °C), but outside it is only 32 °F (0 °C). What is the rate of heat loss through a double-paned glass window of area 1.5 m^2? Each pane is 4.0 mm thick and has a thermal conductivity of 1.0 W m^{-1} K^{-1}. They are separated by 1.0 cm of air (thermal conductivity 0.026 W m^{-1} K^{-1}).

A) 76 W
B) 3.4 kW
C) 3.8 kW
D) 7.5 kW

9. A rectangular block of styrofoam is floating in a pond so that one side of area *A* is facing directly up. The height of the styrofoam from the bottom side to the top side is *h*. The styrofoam block is initially floating in equilibrium.

a) Derive an equation for the distance from the bottom face to the water level (*d*) in terms of the density of the styrofoam (ρ_s) and the water ($\rho_w = 1000$ kg/m^3) and the dimensions of the block (*A* and *h*). (4 points)

b) What is the net force acting on the styrofoam block if it is raised a small distance *y* from its equilibrium position? You may assume that $y < d$. Express your answer in terms of the densities and dimensions as in part (a). (4 points)

c) Show that if we neglect any drag forces by the water, a slight vertical displacement from the styrofoam block's equilibrium position would result in simple harmonic motion. (4 points)

d) What is the angular frequency ω (in terms of densities and dimensions)? (2 points)

10. Starting with Newton's Universal Law of Gravitation, derive Kepler's Third Law (the Law of Periods). You can ignore the mass of the smaller object in your derivation. (14 points)

Answers: 1. D; 2. C; 3. C; 4. B; 5. A; 6. D; 7. C; 8. A; 9. (a) $d = h\,(\rho_s/\rho_w)$; (b) $F_{net} = -\rho_w A y g$; (c) $m a = -k y$, which is a differential equation with a solution of the form $y = y_o \cos(\omega t + \phi)$; (d) $\omega = [(\rho_w g)/(\rho_s h)]^{1/2}$; 10. See p. 334 in text.