Physics 2010-004

Name: SOLUTION KEY

Exam 3A – 16 November 2009

Part A: Hard Multiple Choice (10 points total, 2 points each). Circle best answer.

1. A disk has a momentum of inertia of 396 kg·m^2 and a rotational kinetic energy of 1240 J. What is the angular speed of this disk?

a) 6.26 rad/s (b) 2.50 rad/s c) 0.00 rad/s

d) 0.639 rad/s e) 0.319 rad/s

$KE_r = \frac{1}{2} I \omega^2$, $\omega = \sqrt{\frac{2KE_r}{I}} = \sqrt{\frac{2(1240\ J)}{396\ kg\ m^2}} = 2.50\ rad/s$

2. A 62.2 kg mass sits at -2.40 m on the x axis. A 16.2 kg mass sits at +6.80 m on the x axis. Where does the center of mass lie?

a) 0.00 m (b) -0.499 m c) 1.30 m d) 4.60 m e) -39.2 m

$x_{cg} = \frac{\sum m_i x_i}{\sum m_i} = \frac{(62.2\ kg)(-2.40\ m) + (16.2\ kg)(6.80\ m)}{62.2\ kg + 16.2\ kg} = -0.499\ m$

3. Consider a faucet that delivers water into a sink with a drain. Because of a clog, water drains at 1.0 cm/s through an area of 0.003 m^2. What is the mass flux of water through the drain? (*Hint:* The density of water is 1000 kg/m^3.)

(a) 0.03 kg/s b) 0.3 kg/s c) 3. kg/s d) 30 kg/s e) 300 kg/s

$\text{Mass Flux} = \rho A v = (1000\ kg/m^3)(0.003\ m^2)(1.0 \times 10^{-2}\ m/s) = 0.03\ kg/s$

4. A comfortable room temperature might be 22.5°C. What is this temperature in Kelvin?

a) 22.5 K b) 54.5 K c) 72.5 K d) 250.6 K (e) 295.7 K

$T_c = T - 273.15$, $T = T_c + 273.15 = 22.5 + 273.15 = 295.7\ K$

5. An unknown frozen substance with a latent heat of fusion of 2440 J/kg has just started to melt. If we apply 3.46×10^6 Joules of heat to this icy substance, it will completely melt to liquid. What is the mass of this unknown substance?

a) 0.705 gm b) 133 kg (c) 1420 kg d) 6520 kg e) 8.44×10^9 kg

$Q = mL$, $m = \frac{Q}{L} = \frac{3.46 \times 10^6\ J}{2440\ J/kg} = 1.42 \times 10^3\ kg$

Part B: Easy Multiple Choice (10 points total, 1 point each). Circle best answer.

6. During a phase change, such as when steam condenses to form droplets,

a) heat exchange leads to a temperature increase.

b) heat exchange leads to a temperature decrease.

c) heat exchange drives the phase change.

d) heat exchange changes the mass of the substance in question.

e) there is no heat exchanged.

7. Devices used to measure pressure are called

a) thermometers b) calorimeters c) ergometers

d) barometers e) none of these

8. The conservation of energy for a fluid is given by the equation of

a) Continuity b) Bernoulli c) Poiseuille

d) Archimedes e) Pascal

9. The term "absolute zero" refers to

a) the temperature at which water freezes.

b) the temperature at which carbon dioxide freezes.

c) the zero point in the Fahrenheit scale.

d) the temperature at which all particle motion stops.

e) the coldest temperature ever achieved on Earth.

10. What types of solids have their atoms and molecules arranged in a orderly fashion?

a) crystalline b) amorphous c) opaque

d) dark e) bright

11. *Specific gravity* measures which of the following?

a) acceleration b) density c) latent heat

d) specific heat e) heat capacity

12. Objects that have an emissivity of exactly one are called

a) incompressible b) blackbodies c) non-viscous

d) amorphous e) non-turbulent

13. If a rotating object obeys the conservation of angular momentum, which of the following must be true?

a) $\sum F = 0$ b) $\sum E = 0$ c) $\sum \tau = 0$

d) $E = \eta m c^2$ e) none of these

14. Who was the first to state that pressure applied to an enclosed fluid is transmitted undiminished to every point of the fluid and to the walls of the containing vessel?

a) Continuity b) Bernoulli c) Poiseuille

d) Archimedes e) Pascal

15. Linear acceleration is to angular acceleration as force is to

a) Young's modulus b) angular speed c) torque

d) capacitance e) compressibility

Part C: Problems (20 points total, 10 points each).

16. A spherical asteroid of uniform density of 3220 kg/m^3 and radius of 1920 km is spinning uniformly about an axis completing one revolution in 2.64 days. (a) What is the moment of inertia of this spinning sphere? (*Hint:* You will need to figure out the mass from the density equation. The moment of inertia of a uniform sphere spinning about a center axis is $\frac{2}{5}MR^2$.) (b) What is the rotational kinetic energy of this sphere? (*Hint:* You will need to figure out angular speed from the rotation rate.) (c) What is the angular momentum of this spinning sphere? (**Show <u>all</u> work. *Hint:* Don't forget to make all units consistent!** Needed geometry and physics equations and unit conversions are located on both sides of the Constants/Equations sheet.)

$\rho = 3220\ kg/m^3$, $R = 1920\ km$, $T = 2.64\ days$

a) $I = \frac{2}{5}MR^2$, $\rho = \frac{M}{V}$, $V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi (1920\times10^3\ m)^3$

$= 2.96\times10^{19}\ m^3$

$M = \rho V = (3220\ kg/m^3)(2.96\times10^{19}\ m^3) = 9.55\times10^{22}\ kg$

$I = \frac{2}{5}(9.55\times10^{22}\ kg)(1920\times10^3\ m)^2$

$= \boxed{1.41\times10^{35}\ kg\ m^2}$

b) $KE_r = \frac{1}{2}I\omega^2$, $\omega = \frac{2\pi}{T} = \frac{2\pi\ rad}{(2.64\ d\times8.64\times10^4\ s/d)}$

$= 2.75\times10^{-5}\ rad/s$

$KE_r = \frac{1}{2}(1.41\times10^{35}\ kg\ m^2)(2.75\times10^{-5}\ rad/s)^2$

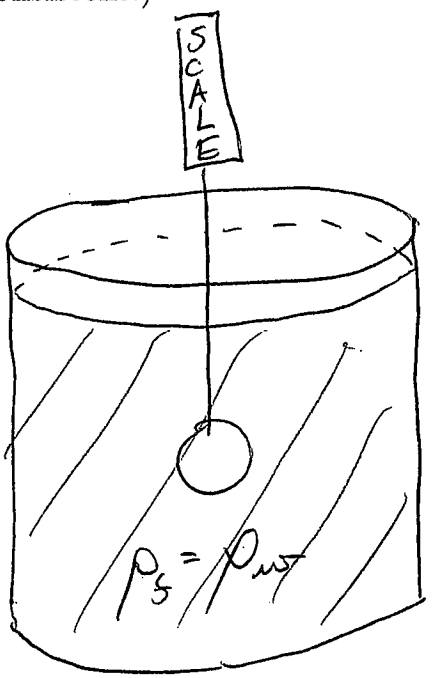
$= \boxed{5.34\times10^{25}\ J}$

c) $L = I\omega = (1.41\times10^{35}\ kg\ m^2)(2.75\times10^{-5}\ rad/s)$

$= \boxed{3.87\times10^{30}\ kg\ m^2/s}$

note that $kg\ m^2/s = J\cdot s$

17. A spherical ball has a mass of 2.66 kg and a radius of 3.34 cm. This ball is suspended from a weight scale. (a) What would be the weight of this ball as measured in the air? (b) What is the volume of this ball in cubic meters? (c) The ball, still suspended from the scale, is now emersed in fresh water. Calculate the effective weight of the ball for this situation. (*Hint:* The density of water is 1000 kg/m^3. **Show <u>all</u> work and make sure your units are consistent!**)



$\rho_w = 1000\ kg/m^3$

a) $w_{air} = mg$

$= (2.66\ kg)(9.80\ m/s^2)$

$= \boxed{26.1\ N}$

b) $V = \frac{4}{3}\pi R^3$

$= \frac{4}{3}\pi (3.34 \times 10^{-2}\ m)^3$

$= \boxed{1.56 \times 10^{-4}\ m^3}$

c) $w_{eff} = mg\left(1 - \frac{\rho_f}{\rho_o}\right) = w_{air}\left(1 - \frac{\rho_w}{\rho_o}\right)$

$\rho_o = \frac{m}{V} = \frac{2.66\ kg}{1.56 \times 10^{-4}\ m^3} = 1.70 \times 10^4\ kg/m^3$

$w_{eff} = (26.1\ N)\left(1 - \frac{10^3\ kg/m^3}{1.70 \times 10^4\ kg/m^3}\right)$

$= (26.1\ N)(1 - 5.87 \times 10^{-2})$

$= \boxed{24.5\ N}$

Extra Credit Problem (5 points, do this only if you have time).

18. A metal rod has a thermal expansion coefficient of $6.44 \times 10^{-5}\,^{\circ}\mathrm{C}^{-1}$. Initially the rod has a temperature of 55.6°F at some initial length. The rod is heated to 412°F which causes it length to change by 3.89 mm. What must have been the initial length of the rod in centimeters? (**Show <u>all</u> work!**)

$\alpha = 6.44 \times 10^{-5}\ ^{\circ}C^{-1}$, $T_0 = 55.6^{\circ}F$, $T = 412^{\circ}F$

$\Delta L = 3.89\ mm$

$T_F = \frac{9}{5}T_C + 32$, $T_C = \frac{5}{9}(T_F - 32)$

$T_0 = \frac{5}{9}(55.6 - 32) = 13.1^{\circ}C$

$T = \frac{5}{9}(412 - 32) = 211^{\circ}C$

$\Delta L = \alpha L_0 \Delta T$, $\Delta T = T - T_0 = 198^{\circ}C$

$$L_0 = \frac{\Delta L}{\alpha \Delta T} = \frac{3.89\ mm}{(6.44 \times 10^{-5}\ ^{\circ}C^{-1})(198^{\circ}C)}$$

$$= 3.05 \times 10^{2}\ mm \times \frac{1\ cm}{10\ mm}$$

$$= \boxed{30.5\ cm}$$