KEY

Physics 101 Test 3 (November 10, 2010)

On multiple choice questions, clearly circle one answer. On short answer questions, please explain your reasoning. On problems 13-15, show all of your work, including a picture, listing known and desired quantities, and the formulas to be used. All questions are worth **5 points** unless otherwise noted.

USEFUL INFORMATION:

$R = 8.31 J/kgK$	$P + \rho gh + \frac{1}{2}\rho v^2 = constant$	$F = \frac{9}{5}C + 32$
$k_B = 1.38x10^{-23} J/K$	$B = (P_b - P_t)A = mg$	$K = C + 273.15$
$N_A = 6.022x10^{23}$	$\rho AV = constant$	$\Delta L = \alpha L_o \Delta T$
$L = I\omega$ $\tau = F_\perp r = I\alpha$	$\rho = m/V$	$PV = nRT = Nk_BT$
		$Q = mL = mc\Delta T$

Water: ρ_{water}=1000 kg/m^3, ρ_{ice}=917 kg/m^3, c_{ice}=2090 J/kg°C, c_{water}=4190 J/kg°C, $L_{icemelting}$=3.33 x 10^5 J/kg

---

1. Two solid metal blocks are placed in an insulated container. If there is a net flow of heat between the blocks, they must have different?

a) Initial temperatures
b) Specific heat values
c) Melting points
d) Heats of fusion
e) Colors

2. What temperature change on the Kelvin scale is equivalent to a 10 degree change on the Celsius scale?

a) 283 K b) 273 K c) 18 K d) 10 K e) 0 K

3. Heat is the...

a) total amount of energy contained in an object
b) average amount of energy per molecule contained in an object
c) energy transferred between objects because of a temperature difference
d) amount of energy all of the molecules have
e) all of the above

4. Water flows through a horizontal pipe. The diameter of the pipe at point B is larger than at point A. At which point is the water pressure greatest?

a) point A b) same at point A and point B c) point B d) not enough information

5. A piece of wood (with a volume of 50 cm^3) is floating on water and is partially submerged. A piece of iron (with a volume of 50 cm^3) is totally submerged in water. Which has the greater buoyant force acting on it?

a) the wood b) the iron c) both have the same buoyant force d) there both have zero buoyant force

6. A wrench is currently in a vertical position attached to an object that needs to be rotated. Where and in what direction should you apply a force on the wrench in order to maximize torque?

a) On the part of the handle closest to the object being acted on with a vertical direction
b) On the part of the handle closest to the object being acted on with a horizontal direction
c) On the part of the handle farthest from the object being acted on with a vertical direction
d) On the part of the handle farthest from the object being acted on with a horizontal direction
e) It doesn't matter. The torque will be the same no matter how the force is applied.

7. A container of an ideal gas is cooled from 600 K to 150 K. What happens to the average speed of the molecules in the container?

a) It decreases by a factor of four.
b) It decreases by a factor of two.
c) It increases by a factor of two.
d) It increases by a factor of four.
e) It stays the same.

8. A constant net nonzero torque is exerted on an object. Which one of the following quantities *cannot* be constant for this object?

a) center of mass b) moment of inertia c) angular momentum d) angular acceleration

9. The fact that heavy airplanes can fly through the air, best illustrates:

a) Pascal's principle
b) Superposition
c) Bernoulli's principle
d) Archimedes' principle
e) Boyles' law

10. Two cylinders of the same size and mass roll down an incline. Cylinder A has most of its weight concentrated at the rim, while cylinder B has most of its weight concentrated at the center. Which reaches the bottom of the incline first?

a) Cylinder A b) Cylinder B c) Both cylinders reach the bottom at the same time

11. The amount of heat required to change a unit of mass of a solid into a liquid, without changing its temperature is referred to as

a) Latent heat of fusion
b) Latent heat of vaporization
c) Latent heat of fission
d) Specific heat
e) Calorimetry

12. In an ideal gas, the quantity PV must be constant when what value is constant?

a) momentum b) velocity c) temperature d) volume e) pressure

13. The average human has a density of 945 kg/m^3 after inhaling and 1020 kg/m^3 after exhaling. Without making any swimming movements, what percentage of the human body would be above the surface in the Dead Sea (a lake with a water density of about 1230 kg/m^3) after inhaling? (6 points)

+2 To float, the buoyant force acting on a person must equal the person's weight. $B = mg$

$\rho = \frac{m}{V}$ $B = \rho_{liquid} g V_{displaced}$ +1 $V_{displaced} = V_{submerged}$ +1

So $\rho_{sea} g V_{displaced} = \rho_{body} g V_{total}$

+1 $\frac{V_{submerged}}{V_{total}} = \frac{\rho_{body}}{\rho_{sea}}$

$\frac{V_{submerged}}{V_{total}} = \frac{945\ kg/m^3}{1230\ kg/m^3} = 76.8\%$

23.2% above surface

After exhaling? (~~2 points~~)

$\frac{V_{submerged}}{V_{total}} = \frac{1020\ kg/m^3}{1230\ kg/m^3} = 0.829 = 82.9\%$ +1

leaving 17.1% above the surface +1

Given that bone ~~and muscle~~ are denser than fat, what two physical characteristics do "**sinkers**" (those who tend to sink in water) have that is different from "floaters" (those who readily float)? (2 points)

In general, sinkers tend to have less fat (thinner) +1 or have heavier bones. +1

14. A 500 g wheel that has a moment of inertia of 0.015 kgm^2 is initially turning at 30 rev/s. It coasts to rest after 163 rev. How large is the torque that slowed it? (10 points)

+2 $\Sigma \tau = I\alpha$ ~~$\tau = rF_\perp$~~

only torque is friction

Knowns Unknown

+2 $\omega_0 = 30\ rev/s$ $\omega_f = 0$ $\Delta\theta = 163\ rev$] $\rightarrow \alpha$

+2 $\omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta$

$\alpha = \frac{\omega_f^2 - \omega_0^2}{2\Delta\theta} = \frac{-(30\ rev/s)^2}{163\ rev} = -5.52\ \frac{rev}{s^2}\left(\frac{2\pi\ rad}{1\ rev}\right) = 34.7\ \frac{rad}{s^2}$

$\tau_{friction} = I\alpha = (0.015\ kgm^2)(34.7\ \frac{rad}{s^2}) = 0.52\ Nm$

(could also do this in terms of work but I don't think many/any students will try this)

15. At a party, 6.00 kg of ice at -5.00°C is added to a cooler holding 30 liters of water at 20.0°C. What is the temperature of the water when it comes to equilibrium? (1000 liters = 1 m³) [10 points] +2

+1 Concept: thermal equilibrium will be reached | $Q_{ice} + Q_{melt} + Q_{ice\text{-}water} + Q_{water} = 0$

+1 $m_{water} = \rho_{water} \times V = (1000\ kg/m^3)(30\ L)\left(\frac{1\ m^3}{1000\ L}\right) = 30\ kg$

$Q_{melt} = mL$ | other Q's $= mc\Delta T$

+3 $0 = m_{ice} c_{ice}(T_f - T_i) + m_{ice} L_f + m_{ice} c_{water}(T_f - T_i) + m_{water} c_{water}(T_f - T_i)$

+2 $0 = (6kg)(2090)(0-(-5)) + (6kg)(3.33\times10^5) + (6kg)(4190)(T_f - 0) + (30kg)(4190)(T_f - 20°)$

$0 = 6.27\times10^4\ J + 2.0\times10^6\ J + (2.51\times10^4\ J/°C)(T - 0°C) + (1.26\times10^5\ J/°C)(T - 20°C)$

solve for T_F $T_F = 3.03\ °C$

16. A spherical steel ball has a diameter of 3.540 cm at 35°C. What is its diameter when its temperature is raised to 100°C? (5 points) α given $11\times10^{-6}(°C)^{-1}$

$d_{new} = \Delta d + d_o = d_o + d_o \alpha \Delta T = d_o(1 + \alpha\Delta T)$ $= (3.540\ cm)[1 + (11\times10^{-6}(°C)^{-1})(100°C - 35°C)]$

$= 3.5425\ cm$ ↑ ✗

What temperature change is required to increase its volume by 1%? (5 points)

$\Delta V = V_o \beta \Delta T$ | $\beta = 3\alpha$

$$\Delta T = \frac{V/V_o}{\beta} = \frac{.01}{3(11\times10^{-6}(°C)^{-1})} = 300\ °C$$

Very little credit for trying to figure it out based on part a and πr^2

Extra Credit. A 60 kg figure skater rotates on the ice. With her arms extended, her initial rotational speed is 0.25 rev/s. But when she draws in her arms, her rotational speed is 0.80 rev/s. For two of these ten points, state the conserved quantity that will help you solve this problem. (2 points)

conservation of angular momentum

Ignoring friction, find the ratio of her moment of inertia in the first case to that in the second. (4 points)

$L_i = L_f$ $\boxed{I_i \omega_i = I_f \omega_f}$ +2

$$\frac{I_i}{I_f} = \frac{\omega_f}{\omega_i} = \frac{0.80 \text{ rev/s}}{0.25 \text{ rev/s}} = 3.2$$

Estimate her body shape as a cylinder rotating along it's long axis ($I = \frac{1}{2} MR^2$). If her final radius is 15 cm, what is her initial effective radius when her hands extended? (2 points)

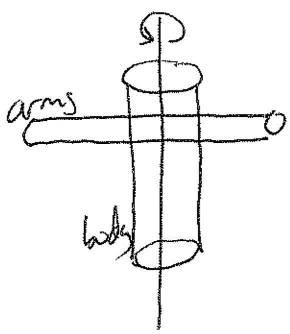
$I_i = 3.2\, I_f$

+1 $\boxed{\frac{1}{2} M R_i^2 = 3.2\left(\frac{1}{2} M R_f^2\right)}$

$$R_i = \sqrt{3.2\, R_f^2} = \sqrt{3.2\,(.15\text{m})^2} = 0.27\text{m} = 27\text{cm}$$

How could we improve upon our estimation of her body shape? (2 points)

While a cylinder is a reasonable estimation for her final position (arms in), it's not as good for her initial position.



You could better estimate her extended arms as a cylinder rotating at its center. The radius of this cylinder would be roughly the length of one arm.