EXAM 1 PHYS 103 Spring 2013 **A**

NAME: Key SECTION________

As a student at NJIT I ______________________, will conduct myself in a professional manner and will comply with the provisions of the NJIT Academic Honor Code. I also understand that I must subscribe to the following pledge on major work submitted for credit as described in the NJIT Academic Honor Code: On my honor, I pledge that I have not violated the provisions of the NJIT Academic Honor Code.

Answer each question on the Scantron card using #2 pencil. Also circle your answers on the question papers. SHOW HOW YOU GOT YOUR ANSWERS ON THE EXAM SHEETS. Use the back if necessary.

1. When an artery gets a constricted region due to plaque, how does the pressure in this region compare to the pressure in an unconstricted region adjacent?

   a. Since this is a closed system, the pressure is the same in both regions.
   b. In the constricted region the blood moves at a higher speed than in the unconstricted region resulting in an increased pressure.
   (c.) In the constricted region the blood moves at a higher speed than in the unconstricted region resulting in a decreased pressure.
   d. In the constricted region the blood moves at a lower speed than in the unconstricted region resulting in an increased pressure.

   $P_1 + \frac{1}{2}\rho v_1 = P_2 + \frac{1}{2}\rho v_2^2$

   $v_1 A_1 = v_2 A_2$

   small A → large v → small P

2. A stonecutter's chisel has an edge area of 0.50 cm^2. If the chisel is struck with a force of 45 N, what is the pressure exerted on the stone?

   a. 9 000 Pa
   b. 90 000 Pa
   c. 450 000 Pa
   (d.) 900 000 Pa
   e. 72 000 Pa

   $P = F/A = \frac{45\,N}{0.50\,cm^2 \times (1\,m/100\,cm)^2}$

3. A uniform pressure of $7.0 \times 10^5\ N/m^2$ is applied to all six sides of a copper cube. What is the percentage change in volume of the cube? (for copper, $B = 14 \times 10^{10}\ N/m^2$)

   a. 2.4×10^{-2} %
   b. 0.4×10^{-2} %
   c. 8.4×10^{-2} %
   (d.) 0.5×10^{-3} %

   $\Delta P = -\beta \frac{\Delta V}{V}$

   $\frac{\Delta V}{V} * 100 = -100 \frac{\Delta P}{\beta} = -100 \left(\frac{7.0 \times 10^5\ N/m^2}{14 \times 10^{10}\ N/m^2}\right)$

   ↑ % change

4. When water freezes, it expands about nine percent. What would be the pressure increase inside your automobile engine block if the water in there froze? (The bulk modulus of ice is 2.0×10^9 Pa, and 1 atm = 1.0×10^5 Pa.)

   a. 18 atm
   b. 270 atm
   c. 1080 atm
   (d.) 1800 atm
   e. 2700 atm

   $\Delta P = -\beta \frac{\Delta V}{V}$

   $= -2.0 \times 10^9\ Pa\,(0.09)\left(\frac{1\ atm}{1.01 \times 10^5\ Pa}\right)$

   $= 1782$ atm

5. The water behind Grand Coulee Dam is 1200 m wide and 150 m deep. Find the approximately hydrostatic force on the back of the dam. (Hint: the total force = average pressure × area)

a. 5.2×10^9 N
b. 8.8×10^{10} N
(c.) 13.2×10^{10} N
d. 18.0×10^{10} N
e. 3.5×10^{11} N

$P_1 = 1$ atm $= 1.01 \times 10^5$ Pa

$P_2 = P_1 + \rho g h = 1.01\times10^5$ pa $+ (1000$ kg/m$^3)(9.8$ m/s$)(150$ m$)$

$P_{avg} = \frac{1}{2}(P_1 + P_2) = 8.4 \times 10^5$ Pa

$F_{ave} = P_{avg} * A = 8.4 \times 10^5$ pa $* (1200$ m $* 150$ m$)$
$= 15 \times 10^{10}$ N

6. A block of wood has density 0.50 g/cm^3 and mass 1 500 g. It floats in a container of oil (the oil's density is 0.75 g/cm^3). What volume of oil does the wood displace?

a. 3 000 cm^3
(b.) 2 000 cm^3
c. 1 500 cm^3
d. 1 000 cm^3
e. 500 cm^3

$V_{oil}\,\rho_{oil} =$ mass of wood

$V_{oil} = \frac{1500\text{g}}{0.75\text{ g/cm}^3} = 2000\text{cm}^3$

7. An ideal fluid, of density 0.85×10^3 kg/m^3, flows at 0.25 kg/s through a pipe of radius 0.010 m. What is the fluid speed?

a. 0.85 m/s
b. 1.3 m/s
c. 3.0 m/s
d. 0.94 m/s
e. 1.74 m/s

$\frac{\Delta V}{\Delta t} = \frac{\Delta x A}{\Delta t} = vA$ or Mass flow rate $= Av\rho$

$v = \left(\frac{\Delta V}{\Delta t}\right)\frac{1}{A} = \left(\frac{0.25\text{ kg/s}}{0.85\times10^3\text{ kg/m}^3}\right) * \frac{1}{\pi(0.010\text{m})^2}$

$= 0.94$ m/s

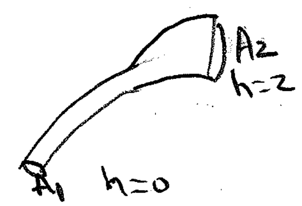
8 Water (density = 1×10^3 kg/m^3) flows at 10 m/s through a pipe with radius 0.030 m. The pipe goes up to the second floor of the building, 2.0 m higher, and the pressure remains unchanged. What is the radius of the pipe on the second floor?

a. 0.046 m
(b.) 0.034 m
c. 0.015 m
d. 0.012 m
e. 0.058 m

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

$\frac{1}{2}v_1^2 = \frac{1}{2}v_2^2 + g h_2$

$v_2 = \sqrt{v_1^2 - 2gh_2} = \sqrt{10^2 - 2(9.8)(2)}$



$A_1 v_1 = A_2 v_2 \rightarrow \pi r_1^2 v_1 = \pi r_2^2 v_2 \rightarrow r_2 = r_1\left(\frac{v_1}{v_2}\right)^{1/2} = 0.034$m

9. The Earth intercepts 1.27×10^{17} W of radiant energy from the Sun. Suppose the Earth, of volume 1.08×10^{21} m^3, was composed of water. How long would it take for the Earth at 0°C to reach 100°C, if none of the energy was radiated or reflected back out into space? $c_{water} = 1.00$ cal/g·°C $= 4186$ J/kg·°C

a. 26.9 y
b. 113 y
c. 2.69×10^4 y
(d.) 1.13×10^5 y
e. 2.69×10^7 y

$Q = mc\Delta T$

$P = Q/t \quad t = Q/P$

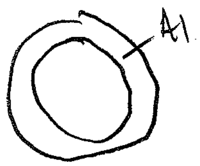
$= \frac{mc\Delta t}{P} = \frac{1000 * 1.08\times10^{21} * 4186 * 100\text{ J}}{1.27\times10^{17}\text{ J/s}}$

$= 3.56 \times 10^{12}$ s

3.56×10^{12} s $/(365$ days $* 24$ hr/day $* 3600$ s/hr$) = 1.13\times10^5$ yrs

10. At 20°C an aluminum ring has an inner diameter of 5.000 cm, and a brass rod has a diameter of 5.050 cm. Keeping the brass rod at 20°C, which of the following temperatures of the ring will allow the ring to just slip over the brass rod? ($\alpha_{Al} = 2.4 \times 10^{-5}$ /C°, $\alpha_{brass} = 1.9 \times 10^{-5}$/C°)

a. 111°C
b. 236°C
c. 384°C
(d.) 437°C
e. 637°C



$\Delta D = \alpha D_0 \Delta T$

$\Delta T = \frac{\Delta D}{\alpha D_0} = \frac{0.05 \text{ cm}}{(2.4 \times 10^{-5}/°C)\, 5 \text{ cm}} = 417$

$T = T_0 + \Delta T = 20 + 417 = 437°$

11. How many atoms are present in a sample of pure iron with a mass of 300 g? (The atomic mass of iron = 56 and $N_A = 6.02 \times 10^{23}$).

a. 1.8×10^{19}
b. 6.7×10^{22}
c. 1.6×10^{28}
(d.) 3.2×10^{24}
e. 1.7×10^{23}

$300 \text{ g} \times \left(\frac{1 \text{ mole}}{56 \text{ g}}\right)(6.022 \times 10^{23} \text{ atoms/mole})$
$= 3.2 \times 10^{24}$ atoms

12. A helium-filled weather balloon has a 0.90 m radius at liftoff where air pressure is 1.0 atm and the temperature is 298 K. When airborne, the temperature is 210 K, and its radius expands to 3.0 m. What is the pressure at the airborne location?

$PV = nRT$ $n, R =$ constant

a. 0.50 atm
b. 0.013 atm
(c.) 0.019 atm
d. 0.38 atm
e. 0.21 atm

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$P_2 = P_1 \left(\frac{V_1}{V_2}\right)\left(\frac{T_2}{T_1}\right)$
$= (1 \text{ atm}) \left(\frac{\frac{4\pi}{3}(0.9^3)}{\frac{4\pi}{3}\, 3^3}\right)\left(\frac{210 \text{ K}}{298}\right) = 0.019$ atm

13. A 3.00-g lead bullet is traveling at a speed of 240 m/s when it embeds in a wood post. If we assume that half of the resultant heat energy generated remains with the bullet, what is the increase in temperature of the embedded bullet? (specific heat of lead = 0.030 5 kcal/kg·°C, 1 kcal = 4 186 J)

(a.) 113°C
b. 137°C
c. 226°C
d. 259°C
e. 520°C

$0.5\left(\frac{1}{2} m v^2\right) = m c \Delta T$

$\Delta T = \frac{0.25 v^2}{c} = \frac{(0.25)(240)^2}{(0.0305 \text{ kcal/(kg °C)})\, 4186 \text{ J/kcal}}$

$= 113 °C$

14. A puddle holds 150 g of water. If 0.50 g of water evaporates from the surface, what is the approximate temperature change of the remaining water? (L_v = 540 cal/g) c_{water} = 1.00 cal/g·°C = 4186 J/kg·°C

a. +1.8 C°
(b.) −1.8 C°
c. +0.18 C°
d. −0.18 C°
e. 0 C°

closed system

$Q = mL_v = (0.5g)(540\ cal/g) = 270\ cal$

evaporate H_2O

$Q_{hot} = -Q_{cold}$

$-270\ cal = (m - m_v)c\Delta T$

$\Delta T = \frac{-270}{(m-m_v)c}$

$\Delta T = \frac{-270}{(150-0.5)\cdot 1\ cal/g°C} = -1.8°C$

15. A windowpane is half a centimeter thick and has an area of 1.0 m^2. The temperature difference between the inside and outside surfaces of the pane is 15° C. What is the rate of heat flow through this window? (Thermal conductivity for glass is 0.84 J/s·m·°C.)

a. 50 000 J/s
(b) 2 500 J/s
c. 1 300 J/s
d. 630 J/s
e. 330 J/s

$P = kA\frac{\Delta T}{\Delta x} = 0.84(1)\frac{15}{0.5\times10^{-2}}$

$= 2500\ J/s$

16. A 100-kg student eats a 200-Calorie doughnut. To "burn it off", he decides to climb the steps of a tall building. How high (in m) would he have to climb to expend an equivalent amount of work? (1 food Calorie = 10^3 calories.)

a. 273
b. 623
c. 418
(d) 854
e. 8400

$Q = 200C * 1000\ c/C * 4.186\ J/c$

$Q = F*d$

$= mgd$

$d = \frac{Q}{mg} = \frac{200 * 1000 * 4.186}{100 * 9.8}\ m$

$= 854\ m$

Bonus

NAME: ______________________________ SECTION________

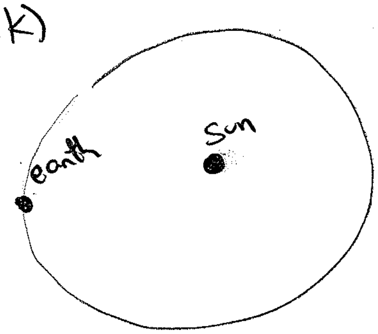
As a student at NJIT I ______________________, will conduct myself in a professional manner and will comply with the provisions of the NJIT Academic Honor Code. I also understand that I must subscribe to the following pledge on major work submitted for credit as described in the NJIT Academic Honor Code: On my honor, I pledge that I have not violated the provisions of the NJIT Academic Honor Code.

Answer each question on the Scantron card using #2 pencil. Also circle your answers on the question papers. SHOW HOW YOU GOT YOUR ANSWERS ON THE EXAM SHEETS. Use the back if necessary.

1. (2 pts) The solar constant is the power received from the sun per unit area perpendicular to the sun's rays as the average distance between the earth and sun (1.5×10^{11} m). The value of the solar constant at the upper atmosphere of the earth is 1.35 kW/m^2 (radius of sun is 6.96×10^8). What is the temperature at the surface of the sun (e=emissivity=1)?

$P = \sigma A e (T^4 - T_0^4)$ ← neglect background (3K)

↑ Output from Sun



$P = A * S = 4\pi R_{SE}^2 S$

$4\pi R_{SE}^2 S = \sigma A e (T^4)$, e = 1, A: sun

$(4\pi R_{SE}^2) S = \sigma 4\pi R_S^2 T^4$

$T^4 = \left(\frac{R_{SE}}{R_S}\right)^2 \frac{S}{\sigma}$

$T = \left(\frac{R_{SE}^2 S}{R_S^2 \sigma}\right)^{1/4}$

$= \left(\frac{(1.5 \times 10^{11} \text{ m})^2 (1.35 \times 10^3 \text{ W/m}^2)}{(6.96 \times 10^8)^2 \, 5.67 \times 10^{-8}}\right)^{1/4}$

$= 5767 \text{ K}$

Equation Sheet

$\rho_w = 1000$ kg/m^3 Pressure = $p = \frac{\mathbf{F}}{\mathbf{A}}$ $\sigma = \frac{\mathbf{F}}{\mathbf{A}}$ $\sigma = \mathbf{Y}\frac{\mathbf{L - L_0}}{\mathbf{L}}$ $p_h = \rho g h$;

$F/A = Y (L-L_0)/L_0$ $F/A = S (L-L_0)/L_0$ $\Delta P = -B (V-V_0)/V_0$

1 atm = 1.013×10^5 Pa, $F_B = \rho g V$ $A_1 v_1 = A_2 v_2$ Av -volume flow rate,
g=9.8 m/s^2

Mass flow rate = $Av\rho$

$p_1 + 1/2\rho v_1^2 + \rho g h_1 = p_2 + 1/2\rho v_2^2 + \rho g h_2$ flow in horizontal pipe: $p_1 + 1/2\rho v_1^2 = p_2 + 1/2\rho v_2^2$

$T(^0C) = \frac{5}{9}\,[T(^0F) - 32]$; $T(^0F) = \frac{9}{5}\,T(^0C) + 32$; $T(K) = [T(^0C) + 273]$ $\Delta T_F = 1.8\,\Delta T_C$

$L - L_0 = \alpha\, L_0\,(T-T_0)$; $A - A_0 = 2\alpha\, A_0\,(T-T_0)$; $V - V_0 = \beta\, V_0\,(T-T_0)$ $V - V_0 = 3\alpha\, V_0\,(T-T_0)$

$\sigma = Y\alpha\,(T-T_0)$ $\rho = \frac{m}{V}$; $A_{circle} = \pi r^2$ 1 m = 100 cm $V_{cube} = a^3$ $V_{sphere} = \frac{4}{3}\pi R^3$

$V_{cyl} = \pi r^2 L$ 1m = 100 cm 1 kg = 1000 g

Kinetic Energy of moving object = ½ m v^2

Potential Energy near surface of earth = m g h, g=9.8 m/s^2

$\frac{Q}{t} = kA\frac{T_1 - T_2}{L}$ $\frac{Q}{t} = A\frac{T_1 - T_2}{\sum R_i}$ **R = L/k** $\frac{Q}{t} = \mathbf{e\sigma A(T^4 - T_0^4)}$ $\sigma = \mathbf{5.67 \times 10^{-8}\ W/m^2K^4}$