Mean = 11.2/19 = 59%   High score = 18/19 = 95%
Std. Dev. = 3.2/20 = 16%   Low score = 3/19 = 16%
KR = 0.66

Phys24-001, Fall 2001 Exam 3

Name Key   PID: ____________   Sequence Number: 101

Honor Pledge and signature:
I have neither given nor received unauthorized aid on this examination. ____________

Instructions:

This exam is closed book, closed notes. However, you may use a calculator.
Mark your answers to the multiple-choice questions on a Scantron answer sheet.
If you do not find your answer, write your solution on these pages and mark option 5.
You may write on these test papers, but partial credit will not be given on the multiple-choice section.
Turn in your Scantron answer sheet and these test papers at the end of the hour.

Equations and conversion factors that may be useful:

$x = x_o + v_{ox}t + \frac{1}{2}a_x t^2$ $\theta = \omega_o t + \frac{1}{2}\alpha t^2$ $\overline{\omega} \equiv \frac{\Delta\theta}{\Delta t}$ $\overline{\alpha} \equiv \frac{\Delta\omega}{\Delta t}$ $a_c = \frac{v_t^2}{r} = r\omega^2$

$v = v_o + at$ $\omega = \omega_0 + \alpha t$ $v_t = r\omega$ $a_t = r\alpha$

$v^2 = v_o^2 + 2ax$ $\omega^2 = \omega_o^2 + 2\alpha\theta$ $E_i = E_f$ $W_{net} = KE_f - KE_i$ $W = (F\cos\theta)d$

$\Sigma \mathbf{F} = m\mathbf{a} = \frac{d\mathbf{p}}{dt}$ $\mathbf{F}\Delta t = \Delta\mathbf{p}$ $\mathbf{p} \equiv m\mathbf{v}$ $KE_t = \frac{1}{2}mv^2$ $PE = mgh$ $f_s \le \mu_s n,\ f_k = \mu_k n$

$\Sigma\tau = I\alpha = \frac{dL}{dt}$ $\tau = Fd$ $L = I\omega$ $KE_r = \frac{1}{2}I\omega^2$ $PE_s = \frac{1}{2}kx^2$ $\overline{P} = \frac{W}{\Delta t} = F\overline{v}$

$F_g = G\frac{m_1 m_2}{r^2}$ $I_{\text{hoop}} = MR^2$ $I_{\text{disk}} = \frac{1}{2}MR^2$ $I_{\text{sphere}} = \frac{2}{5}MR^2$ $I_{\text{rod}} = \frac{1}{3}ML^2$ or $\frac{1}{12}ML^2$

$\text{Elastic modulus} = \frac{\text{stress}}{\text{strain}}$ $\rho = \frac{m}{V}$ $P = \frac{F}{A}$ $P = P_o + \rho gh$ $P + \frac{1}{2}\rho v^2 + \rho gy = \text{const.}$ $A_1 v_1 = A_2 v_2$

$T = T_C + 273.15$ $T_F = \frac{9}{5}T_C + 32$ $\Delta L = \alpha L_o \Delta T$ $\Delta A = \gamma A_o \Delta T$ $\Delta V = \beta V_o \Delta T$ $PV = nRT$

$P = \frac{2}{3}\left(\frac{N}{V}\right)(\frac{1}{2}mv^2)$ $\frac{1}{2}mv^2 = \frac{3}{2}k_B T$ $Q = mc\Delta T$ $Q = mL$ $H = \frac{Q}{\Delta t} = kA\left(\frac{T_2 - T_1}{L}\right)$ $P = \sigma AeT^4$

$\rho_{\text{water}} = 1.00\ \text{g/cm}^3$ $\rho_{\text{ice}} = 0.917\ \text{g/cm}^3$ $\rho_{\text{Al}} = 2.70\ \text{g/cm}^3$ $\rho_{\text{Fe}} = 7.86\ \text{g/cm}^3$ $\rho_{\text{air}} = 1.29\ \text{kg/m}^3$

$c_{\text{water}} = 4186\ \text{J/kg}\cdot°\text{C}$ $c_{\text{ice}} = 2090\ \text{J/kg}\cdot°\text{C}$ $L_{\text{f (water)}} = 3.33\times10^5\ \text{J/kg}$ $L_{\text{v (water)}} = 2.26\times10^6\ \text{J/kg}$

$P_o = 1\ \text{atm} = 1.013\times10^5\ \text{N/m}^2\ (\text{or Pa}) = 14.70\ \text{lb/in}^2$ $1\ \text{cal} = 4186\ \text{J}$ $1\ \text{Btu} = 252\ \text{cal}$ $1\ \text{Cal} = 1\ \text{kcal}$

$1\ \text{m} = 3.28\ \text{ft.}$ $1\ \text{mi} = 1.61\ \text{km}$ $1\ \text{m/s} = 2.24\ \text{mi/h}$ $1\ \text{lb.} = 4.45\ \text{N}$ $1\ \text{hp} = 0.746\ \text{kW}$

$M_{\text{Earth}} = 5.98\times10^{24}\ \text{kg}$ $R_{\text{Earth}} = 6.38\times10^6\ \text{m}$ $G = 6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$ $g = 9.80\ \text{m/s}^2$

N = 47

% Correct — Discrimination — Biserial Correlation[2]

55% 1. A tire stops a car by use of friction. What modulus should be used to calculate the stress and strain on the tire? — 0.25 — 0.31

8 – 1. Young's modulus – length elasticity
3 – 2. Compression modulus – (bulk modulus)$^{-1}$
10 – 3. Bulk modulus – volume elasticity
26 – (4.) Shear modulus – shape elasticity

$$\text{shear modulus} = \frac{\text{shear stress}}{\text{shear strain}}$$

~~2.~~ – omitted because 2 answers are valid.
An aluminum ball has a diameter that is slightly larger than a hole in the center of a steel plate when they are both at room temperature. How can the ball be made to fit through the hole without deforming either the ball or the plate? (Hint: Aluminum has a higher coefficient of linear expansion than steel.) — 0 — 0

Ludwig, Class
32 – (1.) heat the steel plate – best option (most effective)
5 – 2. heat both the ball and plate
6 – (3.) cool both the ball and plate – could also work since aluminum contracts faster than steel
4 – 4. none of the above

15% 3. A brick is tied to a toy balloon that is inflated with just enough air so that it remains suspended just below the surface in a pool of water (the brick and balloon combination are essentially neutrally buoyant). If the balloon is pushed down and then released, what will happen? — 0.26 — 0.38

Class, RWP, Fall 2000
17 – 1. the balloon will rise back up to the surface
7 – (2.) the balloon will sink to the bottom of the pool
22 – 3. the balloon will not float or sink, but will remain at the depth to which it was pushed down
0 – 4. there is not enough information to answer this question

The volume of the balloon decreases as it experiences higher pressure, so its density increases and it sinks.

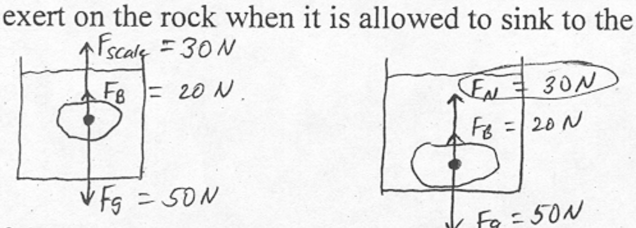
47% 4. An ice cube contains several pebbles that make it heavy enough that it sinks to the bottom of a glass of water. When the ice melts, what happens to the water level in the glass? — 0.62 — 0.45

Class Notes
15 – 1. nothing – the water level stays the same
4 – 2. the water level rises as the ice melts
22 – (3.) the water level falls as the ice melts
6 – 4. the answer depends on the relative size and density of the pebbles

As the ice melts, it displaces less water (ice is less dense than water), so the level in the glass falls.
Note: The answer would be the same even if the ice cub was floating!

36% 5. When a rock is suspended in air by a spring scale, the scale shows a force of 50 N. When the rock is submerged in water (but not touching the bottom), the scale reads 30 N. How much force will the floor of the container exert on the rock when it is allowed to sink to the bottom? — 0.44 — 0.43

Fall 2000 Demo
3 – 1. Zero
14 – 2. 20 N
17 – (3.) 30 N
13 – 4. 50 N



The scale force is simply replaced by the normal force.
The weight and buoyant forces do not change.

96% 6. The zeroth law of thermodynamics pertains to what relational condition that may exist between two systems? — 0.10 — 0.11

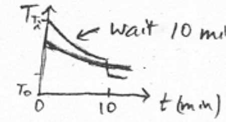
1 – 1. zero net forces
0 – 2. zero velocities
1 – 3. zero temperature
45 – (4.) thermal equilibrium

"Two objects in thermal equilibrium with each other are at the same temperature."

60% 7. You decide to use your physics knowledge to make iced tea by heating a cup of water in a microwave oven and adding tea bags to make a concentrated hot tea. You will then add equal amounts of cold water and ice, but which procedure will yield the coldest pitcher of tea after 10 minutes? 0.72 0.43

28 - (1) Wait 10 minutes for the hot tea to cool, then add cold water and ice
9 - 2. Add cold water, wait 10 minutes, then add ice
2 - 3. Add ice, wait 10 minutes, then add cold water
8 - 4. Add both cold water and ice immediately

The rate of cooling is proportional to ΔT:



77% 8. Some emergency blankets are made of Mylar, which is a thin plastic material that is coated with aluminum. These blankets utilize which heat transfer process to keep a person warm? 0.50 0.49

Class
7 - 1. conduction
4 - 2. convection
36 - (3) radiation
0 - 4. vaporization

The shiny aluminum coating reflects infrared radiation back to the person who is wrapped in the blanket.

28% 9. The internal energy of a gas is most closely related to which quantity? 0.64 0.39

CQ12.4, Class
13 - (1) temperature
4 - 2. pressure
22 - 3. heat
8 - 4. entropy

$U \sim \overline{KE} = \frac{3}{2} k T$

$\Delta U = Q - W$, so the change in internal energy is related to heat and work.

62% 10. A plastic sphere is 1.0 cm in diameter and has a mass of 1.0 g. Will it float in water? 0.42 0.36

13 - 1. yes
29 - (2) no
5 - 3. it depends if the sphere is solid or hollow

$\text{Density} = \frac{m}{V} = \frac{1.0\,g}{\frac{4}{3}\pi (0.05\,cm)^3} = 1.9\ g/cm^3 > \rho_{water} = 1.0\ g/cm^3$

Since the sphere is more dense than water, it will sink.

49% 11. An air bubble has a volume of 0.25 cm^3 when it is at a depth of 20 m in a pool of fresh water. What is its volume just before it reaches the surface? 0.22 0.26

Fall 2000
4 - 1. 0.25 cm^3
12 - 2. 0.50 cm^3
23 - (3) 0.75 cm^3
8 - 4. 1.0 cm^3

0 m — 1 atm; 10 m — 2 atm; 20 m — 3 atm

$P = P_0 + \rho_w g h$

$= 1.013 \times 10^5\ N/m^2 + (1000\ kg/m^3)(9.8\ m/s^2)(20\,m)$

$P = 2.973 \times 10^5\ N/m^2 = 2.93\ atm$

$\therefore V_2 = \frac{P_2}{P_1} V_1 = 2.93\,(0.25\,cm^3) = 0.73\ cm^3$

38% 12. A deflated rubber balloon is placed on a digital balance and found to have a mass of 5.0 g. It is inflated with air to a diameter of 30 cm, and placed on the same balance, which now shows a reading of 5.7 g. What is the magnitude of the buoyant force acting on this inflated round balloon? 0.62 0.51

Demo
10 - 1. 0.0069 N
11 - 2. 0.056 N
8 - 3. 0.14 N
18 - (4) 0.18 N

Buoyant force = weight of air displaced

$F_B = \rho_{air} V g = (1.29\ kg/m^3)\left[\frac{4}{3}\pi (0.15\,m)^3\right](9.8\ m/s^2)$

$F_B = 0.18\ N$

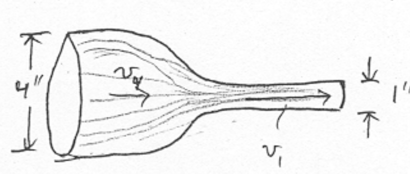
66% 13. An ideal fluid flows through a pipe made of two sections with diameters of 1 and 4 inches, respectively. The speed of the fluid through the 1-inch section will be what factor times that through the 4 inch section? 0.70 0.46

Fall 2000
4 - 1. 4
31 - (2) 16
2 - 3. 1/4
10 - 4. 1/16

Assuming constant flow rate:

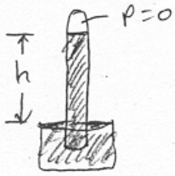
$A_1 v_1 = A_4 v_4$

$\therefore v_1 = \frac{A_4}{A_1} v_4 = \frac{\pi \left(\frac{4}{2}\right)^2}{\pi \left(\frac{1}{2}\right)^2} v_4 = 16\, v_4$



89% 14. If the column of mercury in a barometer stands at 72.6 cm, what is the atmospheric pressure? (The density of mercury is 13.6×10^3 kg/m^3) 0.00 0.04

3 - 1. 0.925×10^5 N/m^2
42 - (2) 0.967×10^5 N/m^2
2 - 3. 1.03×10^5 N/m^2
0 - 4. 1.07×10^5 N/m^2



$P = P_0 + \rho g h$

$P_0 = \rho_{Hg} g h = (13{,}600 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(0.726 \text{ m})$

$P_0 = 9.68 \times 10^4 \text{ N/m}^2$

78% 15. What is the maximum weight that could be supported by a suction cup that is 6 inches in diameter? 0.22 0.21

Fall 2000
6 - 1. 90 lbs.
4 - 2. 140 lbs.
37 - (3) 400 lbs.
0 - 4. 1700 lbs.

If suction cup creates a perfect vacuum, then

$F = P_{air} A = (14.7 \text{ lbs/in}^2)\, \pi (3 \text{ in})^2 = 415 \text{ lbs}$

$F_{max} = 400 \text{ lbs}$

87% 16. Blood flows through a human aorta at a speed of about 50 cm/s. What is the rate of blood flow if the average inner diameter of this heart vessel is 2.0 cm? 0.31 0.34

Fall 2000
0 - 1. 100 cm^3/s
41 - (2) 160 cm^3/s
3 - 3. 310 cm^3/s
3 - 4. 630 cm^3/s

flow rate $= Av = \pi (1.0 \text{ cm})^2 (50 \text{ cm/s}) = 157 \text{ cm}^3/\text{s}$

$= 160 \text{ cm}^3/\text{s}$

62% 17. One mole of an ideal gas is at a pressure of 5.4 atm and a temperature of 22 °C. If the gas is heated at a constant volume until the pressure triples, what is the final temperature? 0.62 0.46

HW 12b
6 - 1. 66 °C
3 - 2. 339 °C
29 - (3) 610 °C
9 - 4. 885 °C

$PV = nRT$ $\quad P_1 = 5.4 \text{ atm}, \; P_2 = 3P_1, \; T_1 = 22°C = 295K$

$\frac{P}{T} = \frac{nR}{V} = \text{const.} \quad \therefore \; T_2 = \frac{P_2}{P_1} T_1 = \frac{3P_1}{P_1}(295K) = 885K = 612°C$

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

53% 18. How much hot water at 70 °C is needed to completely melt 100 g of ice that is initially at a temperature of –10 °C? 0.61 0.48

~Fall 2000, Class Notes
2 - 1. 90 mL
14 - 2. 100 mL
6 - 3. 110 mL
25 - (4) 120 mL

$Q_{lost} = Q_{gained}$

$m_w c_w \Delta T = m_{ice} c_{ice} \Delta T + m_{ice} L_f$

$m_w (4186 \text{ J/kg°C})(70°C) = (0.1 \text{ kg})(2090 \text{ J/kg°C})(10°C) + (0.1 \text{ kg})(3.33 \times 10^5 \text{ J/kg})$

$293{,}000\, m_w = 2090 \text{ J} + 33300 \text{ J}$

$m_w = 0.121 \text{ kg} = 120 \text{ g} \Rightarrow 120 \text{ mL} \quad (\rho_w = 1 \text{ g/mL})$

49% 19. A cup (250 mL) of water is initially at room temperature. Estimate the power of a microwave oven that requires 2.0 minutes on high to bring this cup of water to a boil. 0.63 0.37

Class Notes
9 - 1. 550 W
23 - (2) 650 W
8 - 3. 750 W
7 - 4. 850 W

$P = \frac{Q}{\Delta t} = \frac{mc\Delta T}{\Delta t} = \frac{(0.25 \text{ kg})(4186 \text{ J/kg°C})(100°C - 23°C)}{120 \text{ s}} =$

$P = 670 \text{ W}$

72% 20. The filament temperature of a light bulb is 1000 K when the bulb delivers 20 W of power. If its emissivity remains constant, what power is delivered when the filament is at its rated operating temperature of 2000 K? 0.61 0.51

Fall 2000
Class 11 - 1. 40 W
1 - 2. 100 W
1 - 3. 160 W
34 - (4) 320 W

$P = \sigma A e T^4$

$P_2 = \frac{T_2^4}{T_1^4} P_1 = \frac{(2000K)^4}{(1000K)^4}(20W) = 16(20W) = 320W$