PHYSICS 115 PRACTICE FINAL EXAM A
SOLUTION

Seat No_________

Last Name (Print): ______________________ First Name (Print): _____________________

I certify that the work I shall submit is my own creation, not copied from any source, and that I shall abide by the examination procedures outline below.

Signature: ______________________________ Student ID Number: _________________________

READ THIS ENTIRE PAGE NOW
Do not open the exam until told to do so.
You will have 110 minutes to complete the examination.

NO CELL PHONES, TEXT MSG, etc. ALLOWED AT ANY TIME.

Before the exam begins:

- Print and sign your name, and write your student ID number in the spaces above.
- Write your name, student ID number, and exam version on your bubble sheet and fill in the corresponding "bubbles" using **dark** pencil marks.

During the exam

- When the exam begins, print your name and student ID number on the top of each page. Do this first when you are told to open your exam.
- If you are confused about a question, raise your hand and ask for an explanation.
- If you cannot do one part of a problem, move on to the next part.
- This is a closed book examination. All equations and constants are provided.
- You may use a calculator, but not a computer, or other internet connected devices (smart-phones, iPads, etc.).

For multiple-choice questions:

- Clearly circle your answer choice. Make no stray marks. If you must erase, erase completely.
- Also circle your choices directly on the exam paper for later reference.

End of exam:

- Out of respect to other students, please remain seated for the last 20 minutes of the exam. At the end of the exam, please remain seated until all exams have been collected.

Name ______________________________________ Student ID: ________________ Score: ________
Last First

1. [7 pts] How far above a proton would an electron have to be held to exert an electrostatic force that just equals the weight of the proton? ($m_p = 1.67 \times 10^{-27}$ kg, $m_e = 9.11 \times 10^{-31}$ kg)

A) 14 mm

B) 21 mm

C) 58 mm

D) 0.12 m

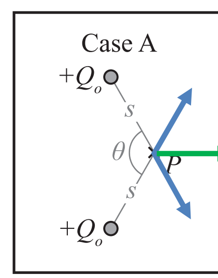
E) 8.4 m

$$F_{elec} = \frac{kq_eq_p}{r^2} = W = m_pg \rightarrow r = \sqrt{\frac{kq_eq_p}{m_pg}}$$

$$r = \sqrt{\frac{(8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2)(1.6 \times 10^{-19} \text{ C})^2}{(1.67 \times 10^{-27} \text{ kg})(9.8 \text{ m/s}^2)}} = 0.12 \text{ m}$$

Questions 2 to 3involve the following situation.

Case A: Point P is a distance s away from two identical positive point charges $+Q_o$. The angle θ is greater than 120°.

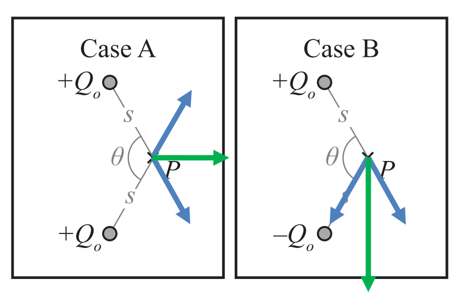


2. [6 pts] Suppose a *negative* test charge were at point P. Which of the following arrows best represents the direction of the **net electric field** experienced by the negative test charge?

A. ↘ B. ↗ C. → D. ↑ E. ←

The electric field points radially away from a positive charge. So, the electric fields of each charge is shown as above. The vector sum of these two fields points to the right.

Case B: The negative test charge is now removed. Suppose one of the positive charges in Case A is replaced by a negative point charge, $-Q_o$ as shown at right.



3. [7 pts] Is the magnitude of the net electric field at point P in Case B *greater than, less than,* or *equal to* that in Case A?

A) Greater than

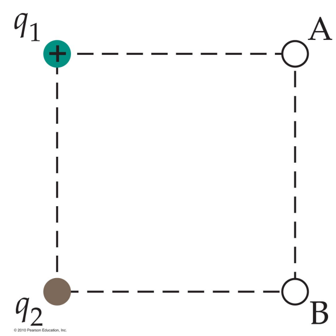
B) Less than

C) Equal to

D) Not enough information

In case A, the net electric field is the sum of the two x-components of the electric fields. Where in case B, the net electric field is the sum of the two y-components of the electric fields. Since the angle θ is greater than 120°, the y-components are larger than the x-components. This means that the net electric field in case B is greater in magnitude than the net electric field in case A.

4. [6 pts] The charge q_1 in the figure at right is positively charged. When a small test charge, $+q_0$, travels from point A to point B, it is known that the net work done by the electric field on the charge is negative. Determine the sign of q_2 and its relative magnitude in comparison to q_1.



A) q_2 is negative, $|q_2| < |q_1|$

B) q_2 is negative, $|q_2| > |q_1|$

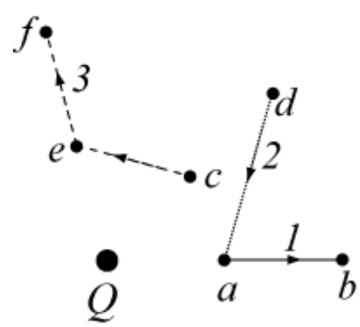
C) q_2 is negative, $|q_2| = |q_1|$

D) q_2 is positive, $|q_2| < |q_1|$

E) q_2 is positive, $|q_2| > |q_1|$

The work done on a charge is given as:
$W_{elec} = -\Delta V q$
Since the charge moving through the potential is positive, and the work done is negative, the change in potential must be positive. For the potential at point B to be more positive than at point A, q_2 must be positive and have a larger magnitude than q_1.

5. [7 pts] A point charge, $+Q$, is fixed in place as shown at right. Points *a*, *c*, and *e* are equidistant from the $+Q$ charge, as are points *b*, *d* and *f*. shown in the diagram at right. A small negative test charge, $-q_0$, travels along three different paths, *1* (*a* to *b*), *2* (*d* to *a*) and *3* (*c* to *e* to *f*). Rank the paths according to the work done by the electric field on the negative test charge. Rank positive work values as larger than negative work values.



A) 3 > 2 > 1

B) 3 = 2 = 1

C) 2 > 1 = 3

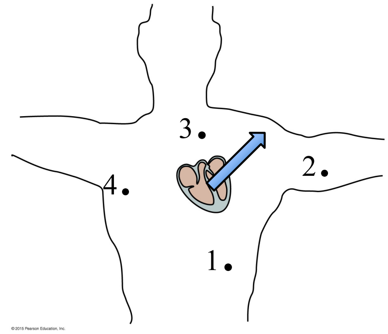
D) 1 = 2 = 3

E) 3 > 1 = 2

In path 1, the force on the charge is to the left and the displacement is to the right. The work done by the field is negative. In path 2, a component of the force is in the same direction as the displacement of the charge. The work done by the field is positive. In path 3, no work is done when the charge moves from point c to point e, since these two points are at the same potential. In moving from point e to point f, the force opposes the displacement and the work is negative. Since the force and displacement have the same magnitude as that along path 1, the works for path 1 and 3 are both negative and have the same magnitude.

Name ___________________________________ Student ID: _______________ Score: _______
Last First

6. [6 pts] The electric dipole moment of the heart at a particular instant is shown below right. Rank the following voltages from most positive to most negative: $V_X = V_3 - V_1$, $V_Y = V_4 - V_1$, and $V_Z = V_4 - V_2$.



A) $V_Z > V_X > V_Y$

B) $V_X > V_Z > V_Y$

C) $V_Z > V_Y > V_X$

D) $V_X = V_Z > V_Y$

E) $V_X > V_Y > V_Z$

Considering the direction of the dipole moment, the potential is positive at points 2 and 3 and negative and points 1 and 4. The potential at points 1 and 4 are approximately the same. V_X *will be positive,* V_Y *will be approximately zero and* V_Z *will be negative.*

7. [7 pts] Capacitor A is a vacuum-filled capacitor formed by circular plates of radius *r*. They are separated by a distance *d*. Capacitor B is formed by circular plates of radius 2*r*. The plates are separated by a distance 3*d* and filled with a dielectric with $\kappa = 9.0$. What is the capacitance of capacitor B in terms of the capacitance of capacitor A?

A) $C_B = 2C_A$	B) $C_B = 4.5C_A$	C) $C_B = 9C_A$	D) $C_B = 12C_A$	E) $C_B = 16C_A$

The capacitance of capacitor A can be written as:

$$C_A = \frac{\kappa_A \varepsilon_0 A_A}{d_A} = \frac{\varepsilon_0 \pi r^2}{d}$$

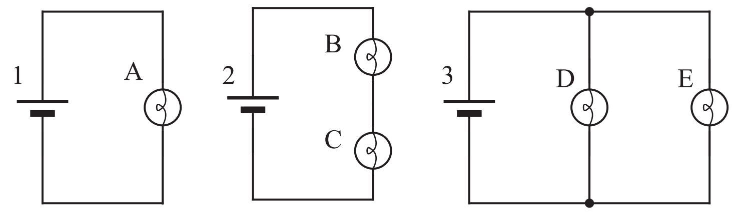
Note that $\kappa_A = 1$, *since it is vacuum-filled.*

The capacitance of capacitor B can be written as:

$$C_B = \frac{\kappa_B \varepsilon_0 A_B}{d_B} = \frac{9\varepsilon_0 \pi (2r)^2}{3d} = \frac{36\varepsilon_0 \pi r^2}{3d} = 12\frac{\varepsilon_0 \pi r^2}{d} = 12C_A$$

Name ________________________________ Student ID: _______________ Score: _______
Last First

8. [6 pts] Consider the three circuits at right. All batteries are ideal and identical, and all bulbs are identical. Rank the current through the three batteries from largest to smallest.



A) 1 > 2 = 3

B) 2 = 3 > 1

C) 2 > 1 > 3

D) 1 = 2 = 3

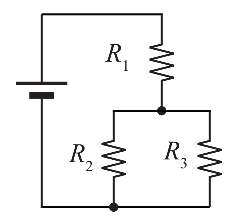
E) 3 > 1 > 2

The current through the battery is inversely proportional to the resistance of each circuit, since all batteries are identical and ideal.

$$I_{battery} = \frac{V_{battery}}{R_{circuit}}$$

If each bulb has a resistance R, circuit 1 has a resistance R, circuit 2 has a resistance 2R (two bulbs in series) and circuit 3 has a resistance R/2 (two bulbs in parallel). Battery 3 will thus have the largest current, followed by battery 1 and then battery 2.

9. [7 pts] Consider the circuit at right, where $R_1 = R$, $R_2 = ½\, R$, and $R_3 = 2R$. The battery has a voltage V. What is the voltage across the resistor, R_1?



A. $5V/7$	B. $3V/5$	C. $5V/6$
D. $8V/11$	E. $11V/13$	

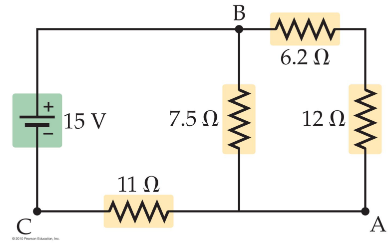
The resistance of the parallel combination is

$R_{23} = \left(\frac{1}{R_2}+\frac{1}{R_3}\right)^{-1} = \left(\frac{2}{R}+\frac{1}{2R}\right)^{-1} = \frac{2R}{5}$ *The voltage across R_1 andt he parallel combination are proportional to their resistances:* $\frac{V_1}{V_{23}} = \frac{R_1}{R_{23}} = \frac{R}{2R/5} = \frac{5}{2}$. *$V_1 + V_{23} = V$, so $V_1 = 5V/7$*

and $V_{23} = 2V/7$.

Name ______________________________________ Student ID: ________________ Score: ________
Last First

10. [7 pts] Consider the circuit shown at right. The current flowing through the battery is 0.92 A. Determine the potential difference across the 12-Ω resistor.



A. 15 V	B. 4.9 V	C. 3.2 V	D. 4.3 V	E. 3.7 V

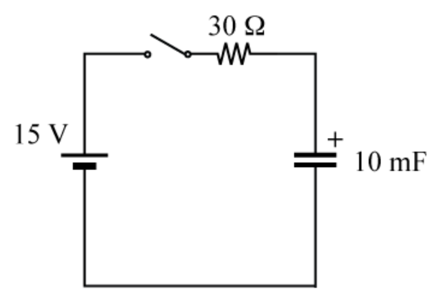
The potential drop across the 11 Ω resistor = (0.92 A)(11 Ω) = 10.1 V

Thus the potential drop V_{BA} *= 15 V – 10.1 V = 4.9 V. The 6.2 Ω and 12 Ω resistors are in series, so* $V_{6.2} + V_{12}$ *= 4.9 V. The potential drop across each resistor is proportional to its resistance:*

$$\frac{V_{6.2}}{V_{12}} = \frac{6.2}{12} = 0.52. \quad \textit{Thus } V_{12} = 4.9 - V_{6.2} = 4.9 - 0.52V_{12} \rightarrow$$

$V_{12} = 3.2\ V$

11. [7 pts] The switch in the *RC* circuit shown at right is closed at $t = 0$. The capacitor is initially uncharged. What is the current through the resistor at the time $t = 0.32$ s?



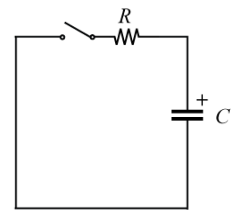
A. 0.27 A	B. 0.39 A	C. 0.45 A
D. 0.17 A	E. 0.33 A	

The value of the current can be determined as follows:

$$I = I_0 e^{-t/RC} = \frac{V}{R} e^{-t/RC} = \frac{15\text{ V}}{30\ \Omega} e^{-0.32\text{ s}/(30\ \Omega)(10\times10^{-3}\text{ F})} = 0.17\text{ A}$$

Name ______________________________ Student ID: _____________ Score: _______
Last First

12. [6 pts] A capacitor is charged to a voltage V. The capacitor is then discharged using the circuit at right. The discharging curve for the RC circuit at right is shown below. Use the information in the graph to determine the RC time constant for this circuit.



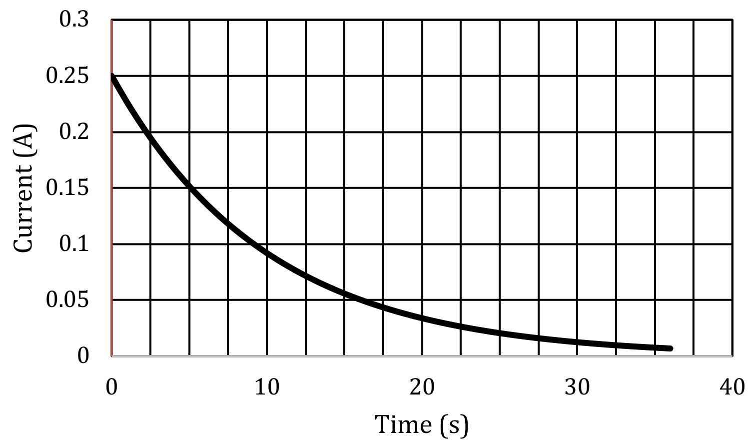
A) 20 s

B) 5.0 s

C) 30 s

D) 2.5 s

E) 10 s



The current through a discharging RC circuit is given as:

$$I = I_0 e^{-t/\tau}$$

The time constant, τ, can be solved as follows:

$$\frac{I}{I_0} = e^{-t/\tau}$$

$$\ln\frac{I}{I_0} = -t/\tau$$

$$\tau = \frac{-t}{\ln\frac{I}{I_0}}$$

The initial current is 0.25 A and the current is 0.15 A at t = 5 s.

$$\tau = \frac{-5\text{ s}}{\ln\frac{0.15\text{ A}}{0.25\ A}} = 10\text{ s}$$

Alternatively, after one time constant, the current should be at 37% of the initial current. 37% of 0.25 A is 0.09 A which corresponds to ~10 s.

Name ___________________________________ Student ID: _______________ Score: _______
Last First

13. [7 pts] A particle with a charge of 14 μC experiences a force of 2.2 x 10^{-4} N when it moves at right angles to a magnetic field with a speed of 27 m/s. What force does this particle experience when it moves with a speed of 6.3 m/s at an angle of 25° relative to the magnetic field?

A. 1.2 x 10^{-5} N	B. 1.8 x 10^{-5} N	C. 2.2 x 10^{-5} N	D. 2.9 x 10^{-5} N	E. 1.5 x 10^{-5} N

The magnetic force on a moving charge is given as:

$$F = qvBsin\phi$$

When the particle moves at right angles to the field, the magnetic field can be written as:

$$B = \frac{F_{90}}{qv_{90}}$$

We can now solve for the force at an angle of 25°:

$$F_{25} = qvBsin(25°) = qv_{25}\frac{F_{90}}{qv_{90}}sin(25°) = F_{90}\frac{v_{25}}{v_{90}}sin(25°)$$

$$F_{25} = (2.2 \times 10^{-4}\ \mathrm{N})\frac{6.3\ \mathrm{m/s}}{27\ \mathrm{m/s}}sin(25°) = 2.2 \times 10^{-5}\ \mathrm{N}$$

14. [7 pts] In a mass spectrometer, charged particles pass through a velocity selector with electric and magnetic fields at right angles to each other, as shown. If the electric field has a magnitude of 450 N/C and the magnetic field has a magnitude of 0.18 T, what speed must the particles have to pass through the selector undeflected?

A. 1500 m/s	B. 1800 m/s	C. 2000 m/s	D. 2200 m/s	E. 2500 m/s

$$v = \frac{E}{B} = \frac{450\ \mathrm{N/C}}{0.18\ \mathrm{T}} = 2500\ \mathrm{m/s}$$

15. [7 pts] An electron accelerated from rest through a voltage of 750 V enters a region of constant magnetic field. If the electron follows a circular path with a radius of 27 cm, what is the magnitude of the magnetic field?

A. 5.1 mT	B. 0.34 mT	C. 4.8 mT	D. 0.26 mT	E. 0.64 mT

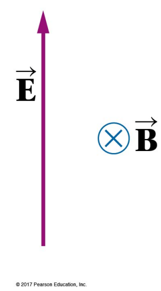
$$B = \frac{mv}{rq} = \frac{m\left(\sqrt{\frac{2(qV)}{m}}\right)}{rq} = \frac{\sqrt{2}m^{1/2}q^{1/2}V^{1/2}}{rq} = \frac{\sqrt{2}m^{1/2}q^{-1/2}V^{1/2}}{r} = \frac{\sqrt{2}(9.11 \times 10^{-31})^{1/2}q^{-1/2}V^{1/2}}{r}$$

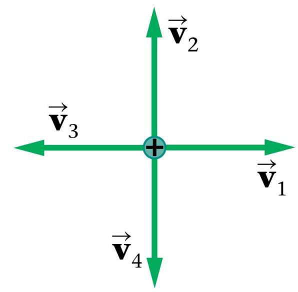
$$B = \frac{\sqrt{2}(9.11 \times 10^{-31})^{1/2}(1.6 \times 10^{-19}\mathrm{C})^{-1/2}(750)^{1/2}}{0.27\ \mathrm{m}} = 0.00034\ \mathrm{T} = 0.34\ \mathrm{mT}$$

Name ______________________________ Student ID: ____________ Score: _______

Last First

16. [7 pts] A positively charged particle moves through a region with a uniform electric field pointing toward the top of the page and a uniform magnetic field pointing into the page. The particle can have four velocities as shown. Rank the four possibilities in order of decreasing magnitude of net force.





A) $|v_1| > |v_2| > |v_3| = |v_4|$

B) $|v_2| = |v_4| > |v_3| = |v_1|$

C) $|v_1| > |v_2| = |v_4| > |v_3|$

D) $|v_1| > |v_2| > |v_4| > |v_3|$

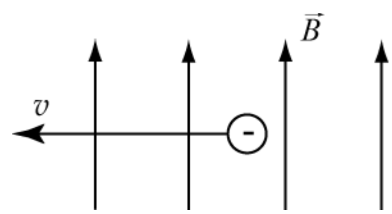
E) $|v_2| = |v_4| > |v_1| = |v_3|$

The electric force is independent of the speed of the charged particle. Since the particle is positively charged and the electric field is upward, the electric force is upward in each case.

For v_1, the magnetic force is upward by the right hand rule (RHR). For v_2, the magnetic force is to the left by the right hand rule (RHR). For v_3, the magnetic force is downward by the right hand rule (RHR). For v_4, the magnetic force is to the right by the right hand rule (RHR).

Considering the vector sum of these two forces, the sum for v_1 would be largest, followed by v_2 which is equal to v_4 and the smallest force would be that for v_3.

17. [6 pts] A *negative* charge moves with a velocity in the negative *x*-direction through a region of uniform magnetic field. The magnetic field points in the positive *y*-direction. What is the direction of the magnetic force on the positive charge?



A) Into the page

B) Out of the page

C) Positive y-direction (up the page)

D) Negative y-direction (down the page)

E) Positive x-direction (to the right)

Name ________________________________ Student ID: ______________ Score: _______
Last First

18. [7 pts] The Seattle-to-Portland bike race is scheduled each July and cyclists can choose to cover the 205 miles in one or two days. Suppose you were to enter the race and want to complete the total distance in 1 day. You determine that you ride your bike at an average speed of 25.0 km per hour, which requires a total metabolic power of 550 W. If you plan to fuel your journey by making 12 rest-stops, how many Calories do you need to consume at each rest-stop? (1 mile = 1610 m)

A) 120 Cal	B) 350 Cal	C) 520 Cal	D) 740 Cal	E) 890 Cal

The total distance of the bike trip is 330 km as shown below.

$$\Delta x = 205\ miles = (205\ \text{miles})\left(1.61\ \frac{\text{km}}{\text{mile}}\right) = 330\ \text{km}$$

The time taken to complete the trip can be determined as follows.

$$\Delta t = \frac{\Delta x}{v} = \frac{330\ \text{km}}{25\ \text{km/hr}} = 13.2\ hours = 13.2\ \text{hours}\left(3600\ \frac{\text{s}}{\text{hr}}\right) = 4.75\ \times\ 10^4\ \text{s}$$

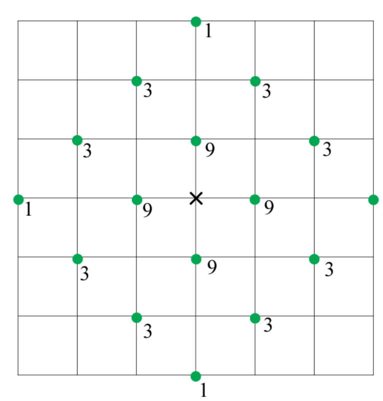
The total energy burned during this trip can be calculated as follows:

$$E_{total} = (Metabolic\ Power)(time) = (550\ \text{W})(4.75\ \times\ 10^4\ \text{s}) = 2.61\ \times\ 10^7\ \text{J}$$

$$E_{total} = \frac{(2.61\ \times\ 10^7\ \text{J})}{4190\ \frac{\text{J}}{\text{Cal}}} = 6239\ Cal$$

To have enough energy for the ride, the cyclist needs to consume these calories over 12 rest-stops "meals". Therefore for each rest-stop, the cyclist will consume 520 Calories.

19. [7 pts] Your physics instructor completes a 1000 trials of a 3-step, 2-D random walk. Your instructor can only move upward, downward, right or left. The "x" in the figure represents the starting position of your instructor and the green circles represent his possible final locations. The number in the diagram represents the number of microstates that correspond to that particular location. If the width of one box represents one step, how many times will the instructor end up at $\sqrt{5}$ steps from his starting point?



A) ~50 times

B) ~190 times

C) ~250 times

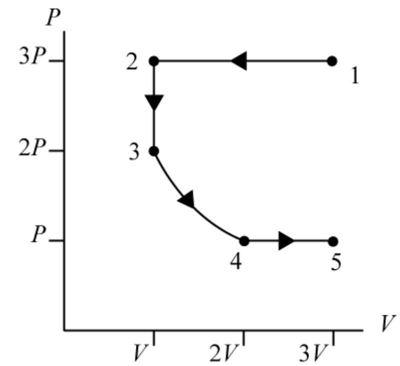
D) ~375 times

E) ~550 times

Each of the green circles with a number "3" represent a distance of $\sqrt{5}$ steps from the starting location. There is a total of 64 microstates and there are 24 microstates that refer to the location in question. The probability of this location is therefore 24/64 which equals 0.375. From a 1000 trials, the physics instructor should find himself at that location approximately 375 times.

Name ____________________________________ Student ID: _______________ Score: _______
Last First

Consider the graph at right for questions 3 and 4.
The pV diagram at right illustrates four different processes which takes a gas from state 1 to state 5. The process between state 3 and 4 is an isothermal process.



20. [6 pts] Is the net work done on the gas *positive, negative,* or *zero?* Explain.

A) Positive

B) Negative

C) Zero

D) Not possible to answer

The work done on the gas is equal to the negative of the area under the pV curve. In process 1 to 2, there is a large amount of positive work done (9PV) since the gas is compressed. There is no work done in process 2 to 3 since this is an isochoric process. There is negative work done on the gas in process 3 to 4 and in process 4 to 5, but the area under these curves is less than the area under the curve in the process 1 to 2. Therefore, the net work done on the gas is positive.

21. [7 pts] Rank the absolute value of the heat transferred with the gas in each of the following processes:

- $Process\ 1 \to 2$
- $Process\ 2 \to 3$
- $Process\ 3 \to 4$
- $Process\ 4 \to 5$

A) $|Q_{4\to5}| > |Q_{2\to3}| = |Q_{3\to4}| > |Q_{1\to2}|$

B) $|Q_{1\to2}| > |Q_{4\to5}| = |Q_{3\to4}| > |Q_{2\to3}|$

C) $|Q_{1\to2}| > |Q_{4\to5}| > |Q_{2\to3}| > |Q_{3\to4}|$

D) $|Q_{2\to3}| > |Q_{3\to4}| > |Q_{4\to5}| > |Q_{1\to2}|$

E) Other

The first law of thermodynamics states: $W + Q = \frac{3}{2}Nk_B\Delta T = \frac{3}{2}\left[(PV)_f - (PV)_i\right]$

$$Q_{1\to2} = \frac{3}{2}\left[(PV)_f - (PV)_i\right] - W = \frac{3}{2}[-6PV] - 6PV = -15PV \qquad |Q_{1\to2}| = 15PV$$

$$Q_{2\to3} = \frac{3}{2}\left[(PV)_f - (PV)_i\right] = \frac{3}{2}[-PV] = -\frac{3}{2}PV \qquad |Q_{2\to3}| = 1.5PV$$

$$Q_{3\to 4} = \frac{3}{2}\left[(PV)_f - (PV)_i\right] - W = 0PV - \left(-2PV\ln\frac{2V}{V}\right) = 1.4PV \qquad |Q_{3\to 4}| = 1.4PV$$

$$Q_{4\to 5} = \frac{3}{2}\left[(PV)_f - (PV)_i\right] - W = \frac{3}{2}[PV] - (-PV) = 2.5PV \qquad |Q_{4\to 5}| = 2.5PV$$

22. [7 pts] At 18.75°C a brass sleeve has a diameter of 2.21988 cm and a steel shaft has a diameter of 2.22258 cm. To what temperature must the sleeve be heated in order for it to slip over the shaft? $\alpha_{brass} = 19 \times 10^{-6}\ \text{K}^{-1}$, $\alpha_{steel} = 12 \times 10^{-6}\ \text{K}^{-1}$

A) 64°C	B) 83°C	C) 140°C	D) 101°C	E) 120°C

$$\Delta l = \alpha l_0 (T_f - T_i)$$

$$T_f = \frac{\Delta l}{\alpha l_0} + T_i = 83°\text{C}$$

23. [7 pts] A laboratory technician drops an 85.0 g solid sample of unknown material at a temperature of 100.0°C into a well-insulated copper can. The copper can has a mass of 0.150 kg and contains 0.200 kg of water, and both the can and the water are initially at 19.0°C. The final temperature of the system is measured to be 26.1°C. Compute the specific heat capacity of the sample.
(c_{copper} = 390 J/kg-K, c_{water} = 4190 J/kg-K)

A) 2.51×10^3 J/kg-K	B) 1.01×10^3 J/kg-K	C) 0.912×10^3 J/kg-K	D) 1.62×10^3 J/kg-K	E) 2.11×10^3 J/kg-K

$$Q_{net} = 0$$

$$Q_{sample} + Q_{water} + Q_{copper} = 0$$

$$m_s c_s \Delta T_s + m_w c_w \Delta T_w + m_c c_c \Delta T_c = 0$$

$$c_s = \frac{-m_w c_w \Delta T_w - m_c c_c \Delta T_c}{m_s \Delta T_s} = \frac{-(0.2\text{kg})(4190\text{J/kg-K})(7.1\text{K}) - (0.15\text{kg})(390\text{J/kg-K})(7.1\text{K})}{(0.085\text{kg})(-73.9\text{K})}$$

$$c_s = 1.01\times10^3\ \text{J/kg-K}$$

Name ______________________________ Student ID: ____________ Score: _______
Last First

24. [6 pts] A window has dimensions of 1.40 m x 2.50 m and is made of glass with a thickness d. On a winter day, the outside temperature is -20.0°C, while the inside temperature is a comfortable 19.56°C. The rate of heat loss by conduction is known to be 2.13 x 10^4 W. Determine the thickness of the window. (k_{glass} = 0.8 W/m-K)

A) 3.49 mm	B) 4.31 mm	C) 5.20 mm	D) 6.71 mm	E) 7.48 mm

$$Q = kA\frac{\Delta T}{\Delta l}$$

$$\Delta l = kA\frac{\Delta T}{Q} = 5.20 \text{ mm}$$

25. [7 pts] A container holds 1.0 g of oxygen at a pressure of 8.0 atm. How much heat is required to increase the temperature by 100.0 °C at constant pressure? $M_{oxygen} = 32$ g/mol

A) 15 J	B) 28 J	C) 49 J	D) 55 J	E) 65 J

$$Q = nC_p\Delta T = \left(\frac{1.0\text{ g}}{32\text{ g/mol}}\right)\frac{5}{2}\left(8.31\frac{\text{J}}{\text{mol. K}}\right)(100\text{ K}) = 65\text{ J}$$

26. [7 pts] Carbon dioxide enters a green leaf, where photosynthesis occurs, by diffusing through small cylindrical pores called stomata, with a depth of 12.0 μm and diameter d. The rate of transfer of molecules through each stomata is 1.20×10^{10} mol/s and the diffusion constant for CO_2 is $1.90 \times 10^{-5}\ \text{m}^2/\text{s}$. If the concentration difference of CO_2 in the air and the leaf is $0.50 \times 10^{22}\ \text{m}^{-3}$, what is the diameter of the stomata?

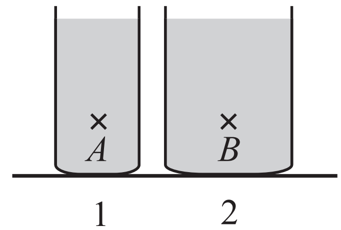
A) 0.59 μm	B) 1.4 μm	C) 2.5 μm	D) 3.9 μm	E) 5.1 μm

$$\frac{N}{\Delta t} = \left(\frac{DA}{L}\right)\Delta c = \left(\frac{D\frac{\pi}{4}d^2}{L}\right)\Delta c$$

$$d = \sqrt{\frac{\left(\frac{N}{\Delta t}\right)4L}{\Delta c D\pi}} = \sqrt{\frac{(1.20 \times 10^{10}\text{ mol/s})4(12.0 \times 10^{-6}\text{ m})}{(0.50 \times 10^{22}\text{ m}^{-3})(1.90 \times 10^{-5}\text{ m}^2/\text{s})\pi}} = 1.4 \times 10^{-6}\text{ m} = 1.4\ \mu\text{m}$$

Name ________________________________ Student ID: _______________ Score: _______
Last First

27. [6 pts] Two cylindrical containers, 1 and 2, contain different unknown liquids. The heights of the liquids in containers 1 and 2 are equal. The masses of the liquids in containers 1 and 2 are also equal. (Note that the diameter of container 2 is greater than that of container 1.) Is the pressure at point *A* *greater than, less than,* or *equal to* that at point *B*?



A) Greater than

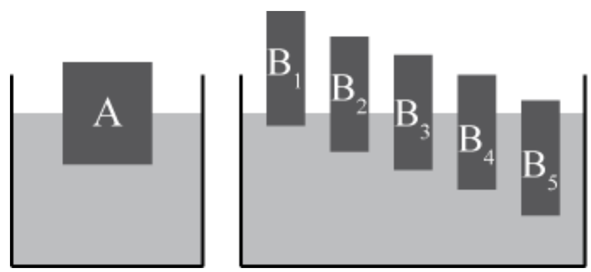
B) Less than

C) Equal to

D) Not enough information to answer.

The masses of the liquids are the same but the volume of container 2 is larger, so the density of the liquid in container 2 must be smaller than the density of the liquid in container 1. Points A and B are at the same depth and the surfaces of the two liquids are at atmospheric pressure. The increase in pressure as depth increases is proportional to the density of the liquid, so the pressure at A must be larger than the pressure at B since liquid 1 is more dense.

28. [7 pts] Block A of mass *m* and volume *V* floats in a fluid of density ρ as shown. Half of block A is submerged. Block B of mass 2*m* and 3*V* is placed in a container with the same fluid density. Which of the blocks, 1-5 best represents the location of block B in its container? $F_B = W$



A) 1

B) 2

C) 3

D) 4

E) 5

Object A

$F_B = W$

$\rho_f g V_{sub} = \rho_A g V_A$

$V_{sub} = \frac{V_A}{2}$

$\rho_f g \frac{V_A}{2} = \rho_A g V_A$

$\rho_f = 2\rho_A$

Object B

$F_B = W$

$\rho_f g V_{sub} = \rho_B g V_B$

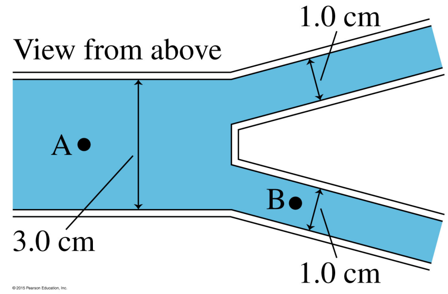
$\rho_f = 2\rho_A \quad \rho_B = \frac{2}{3}\rho_A$

$2\rho_A g V_{sub} = \frac{2}{3}\rho_A g V_B$

$V_{sub} = \frac{1}{3} V_B$

Name ______________________________ Student ID: ______________ Score: _______
Last First

29. [7 pts] The 3.0-cm diameter water line shown at right splits into two 1.0-cm diameter pipes. All pipes are circular and at the same elevation. At point A, the water speed is 2.0 m/s and the gauge pressure is 50 kPa. What is the gauge pressure at point B?



A) 12 kPa

B) 22 kPa

C) 29 kPa

D) 38 kPa

E) 42 kPa

$$A_A v_A = 2(A_B v_B)$$

$$v_B = \frac{A_A v_A}{2A_B}$$

$$P_A + \frac{1}{2}\rho v_A^2 = P_B + \frac{1}{2}\rho v_B^2$$

$$P_A + \frac{1}{2}\rho v_A^2 = P_B + \frac{1}{2}\rho \frac{A_A^2 v_A^2}{4A_B^2}$$

$$P_B = P_A + \frac{1}{2}\rho v_A^2 - \frac{1}{2}\rho \frac{A_A^2 v_A^2}{4A_B^2} = P_A + \frac{1}{2}\rho v_A^2\left(1 - \frac{A_A^2}{4A_B^2}\right) = 11{,}500 \text{ Pa} \approx 12 \text{ kPa}$$

Name ____________________________________ Student ID: _______________ Score: _______
Last First

30. [6 pts] An average adult has a flow rate Q through an artery of length L and diameter d. The viscosity of blood at normal hematocrit is about 4.750 mPa-s. An athlete who uses the performance enhancing drug, EPO, increases their hematocrit level which causes the blood viscosity to increase to 5.000 mPa-s. The athlete's artery of length L also has a slightly dilated diameter of $1.020d$. If the pressure difference across the arteries are the same, what is the blood flow rate for the athlete?

A) $1.007Q$

B) $1.013Q$

C) $1.028Q$

D) $1.045Q$

E) $1.068Q$

The flow rate for a viscous fluid is given as:

$$Q = \frac{\pi r^4 \Delta p}{8\eta L}$$

We can setup a ratio of the flow rates in the athlete to that of the average adult:

$$\frac{Q_{athlete}}{Q_{avg\ adult}} = \frac{\dfrac{\pi(1.020d)^4\Delta p}{8(5.000\ \mathrm{mPa.s})L}}{\dfrac{\pi(d)^4\Delta p}{8(4.750\ \mathrm{mPa.s})L}} = \frac{1.020^4}{5.000\ \mathrm{mPa.s}} 4.750\ \mathrm{mPa.s.} = 1.028$$

$$Q_{athlete} = 1.028 Q_{avg\ adult}$$