

**University of Ottawa**  
**Department of Physics**  
**PHY1122(A) - Fundamentals of Physics II**  
**Final Examination - April 24, 2014**  
**Examiner: M. Rogers**

This is a closed book exam.  
You are allowed a two-sided sheet of hand-written notes  
on  $8.5 \times 11$  inch paper, and a calculator.  
Answer all questions, worth a total of 100 marks.  
You have 180 minutes.

**PART I: Multiple choice (30 Marks).** Questions 1-10 are worth 3 marks each. Each multiple choice question must be answered on the optically-read response sheet provided, NOT in the examination booklet.

**Question 1 (3 marks)** Heat from the Sun reaches Earth because of which type of heat transfer?

- (a) conduction
- (b) convection
- (c) advection
- (d) radiation

**Question 2 (3 marks)** Fire Syringe: When a small, thin, piston-cylinder arrangement is quickly compressed, a piece of cotton sitting inside it ignites. This process is best described as

- (a) an isothermal compression.
- (b) an isobaric compression.
- (c) an adiabatic compression.
- (d) magic.

**Question 3 (3 marks)** Fluid is moving through a tube as shown in Figure 1. The cross sectional area  $A_2$  is exactly half of the cross sectional area  $A_1$ . What statement about the relationship between velocities  $v_1$  and  $v_2$  is correct?

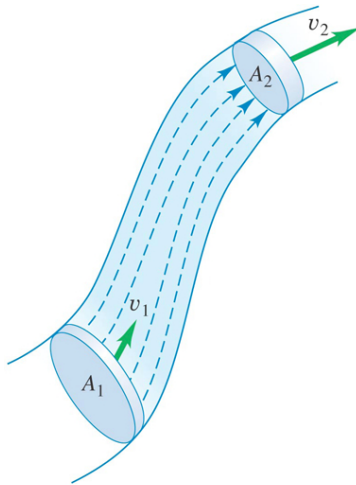


Figure 1: Fluid flowing in tube for Question 3.

- (a)  $v_1$  is twice the magnitude of  $v_2$ .
- (b)  $v_1$  is half of the magnitude of  $v_2$ .
- (c)  $v_1$  is a quarter of the magnitude of  $v_2$ .
- (d)  $v_1$  is four times the magnitude of  $v_2$ .

**Question 4 (3 marks)** The equipartition of energy principle states that each degree of freedom has  $\frac{1}{2}kT$  of kinetic energy associated with it. How many degrees of freedom does a diatomic gas molecule have?

- (a) 3
- (b) 4
- (c) 5
- (d) 6

**Question 5 (3 marks)** A reversible thermodynamic process is one in which

- (a) energy does not change.
- (b) estrogen does not change.
- (c) enstrophy does not change.
- (d) entropy does not change.

**Question 6 (3 marks)** After laser light passes through a thin slit, it forms a pattern on a screen that has a series of light and dark fringes. This is called a

- (a) diffusion pattern.
- (b) differential pattern.
- (c) diffraction pattern.
- (d) dielectric pattern.

**Question 7 (3 marks)** The Carnot cycle, shown in Figure 2, has

- (a) two adiabatic segments and two isothermal segments.
- (b) two adiabatic segments and two isochoric segments.
- (c) two isothermal segments and two isochoric segments.
- (d) two isothermal segments and two isobaric segments.

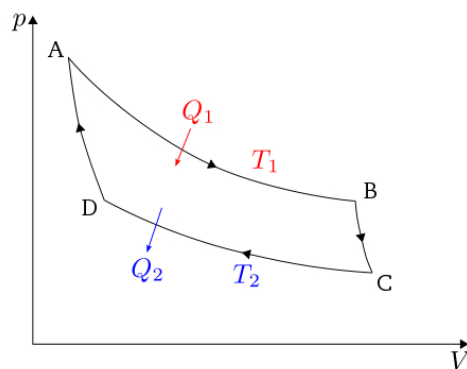


Figure 2: The Carnot cycle.

**Question 8 (3 marks)** A dielectric is

- (a) a nonconducting material.
- (b) a conducting material.
- (c) a type of pattern with light and dark fringes.
- (d) another name for a capacitor.

**Question 9 (3 marks)** You are walking through a wooded area during a light rain. As you come towards a clearing, you notice a beautiful pattern in the sky: a double rainbow. The brighter rainbow on the bottom has red on top and violet on bottom. The rainbow above it has red on the bottom and violet on top. You ask yourself “what does this mean?”. Then you remember that you took PHY1122, and that the darker second rainbow must have come from

- (a) reflection of the image of the first rainbow on raindrops in the sky.
- (b) a single internal reflection of sunlight inside raindrops in the sky.
- (c) two internal reflections of sunlight inside raindrops in the sky.
- (d) an optical illusion.

**Question 10 (3 marks)** A box encloses a positive point charge  $+q$ . If the dimensions of the box are doubled, the electric flux

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

**PART II: Problem solving (70 Marks).** Questions 11-17 are worth 10 marks each. Each of these questions must be answered in the examination booklet provided.

**Question 11 (10 marks)** In Figure 3, where  $V_{23} = 3.00V_1$ ,  $n$  moles of a diatomic ideal gas are taken through the cycle with the molecules rotating but not oscillating ( $C_V = \frac{5R}{2}$ ). Calculate:

- (a) **(4 Marks)** The heat  $Q_{12}$  for process  $1 \rightarrow 2$ .
- (b) **(3 Marks)** The work  $W_{23}$  for process  $2 \rightarrow 3$ .
- (c) **(3 Marks)** The heat  $Q_{31}$  for process  $3 \rightarrow 1$ .

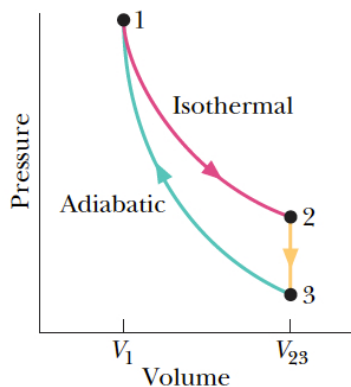


Figure 3: Thermodynamic cycle for Question 11.

**Question 12 (10 marks)** Determine the current in each of the three branches of the circuit shown in Figure 4. One branch has an  $8.00\Omega$  resistor, a second branch includes the  $4.00\text{ V}$  emf, and the third branch includes the  $12.0\text{ V}$  emf.

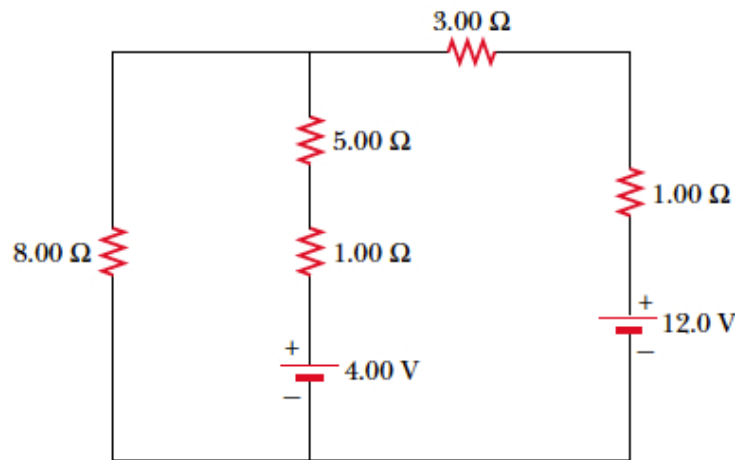


Figure 4: Circuit for Question 12.

**Question 13 (10 marks)**

- (a) **(5 Marks)** A light ray initially in water ( $n_{\text{water}} = 1.333$ ) enters a transparent substance at an angle of incidence of  $\theta_1 = 37.0^\circ$ , and the transmitted ray is refracted at an angle of  $\theta_2 = 25.0^\circ$ . Calculate the speed of light in the transparent substance. The speed of light in vacuum is  $3.00 \times 10^8\text{ m/s}$ .
- (b) **(5 Marks)** Unpolarized light in vacuum ( $n_{\text{vac}} = 1$ ) is incident upon a sheet of glass with index of refraction  $n$ . The reflected and refracted rays are perpendicular to each other. Find the angle of incidence  $\theta_1$  in terms of  $n$ . This angle is called *Brewster's angle*.



**Question 14 (10 marks)** A solid, insulating sphere of radius  $a$  has a uniform charge density  $\rho$  and a total charge  $Q$ . Concentric with this sphere is an uncharged, conducting hollow sphere whose inner and outer radii are  $b$  and  $c$ , as shown in Figure 5. Find the magnitude of the electric field in the regions  $r < a$ ,  $a < r < b$ ,  $b < r < c$ , and  $r > c$ .

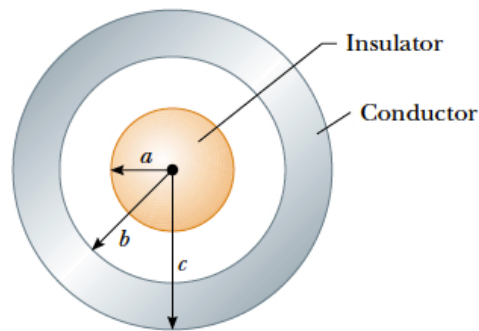


Figure 5: Concentric conducting shell and insulating sphere.

**Question 15 (10 marks)** A small metal sphere, carrying a net charge of  $q_1 = -2.80 \times 10^{-6}\text{C}$ , is held in a stationary position by insulating supports, as shown in Figure 6. A second small metal sphere, with a net charge of  $q_2 = -7.80 \times 10^{-6}\text{C}$  and mass 1.50 g, is projected toward  $q_1$ . When the two spheres are 0.800 m apart,  $q_2$  is moving toward  $q_1$  with speed 22.0 m/s. Assume that the two spheres can be treated as point charges, and that you can ignore the force of gravity. How close does  $q_2$  get to  $q_1$ ?

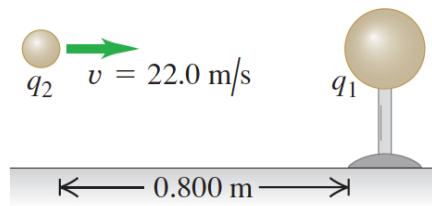


Figure 6: Figure for Question 15.

**Question 16 (10 marks)**

- (a) **(5 Marks)** Figure 7 shows a system of four capacitors, where the potential difference across  $ab$  is 50.0 V. (i) Find the equivalent capacitance of this system between  $a$  and  $b$ . (ii) How much charge is stored by this combination of capacitors?

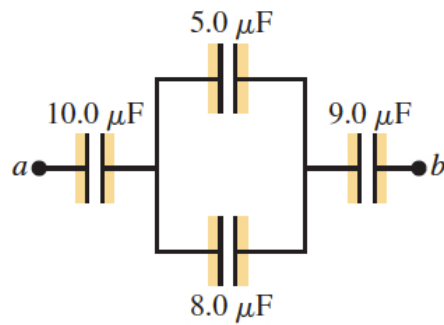


Figure 7: Four capacitor arrangement for Question 16.

- (b) **(5 Marks)** An  $RC$  circuit has a resistor with  $R = 1.00 \times 10^6 \, \Omega$  and a capacitor with  $C = 5.00 \times 10^{-6} \, \text{F}$ . Find (i) the time constant of the circuit and (ii) the maximum charge on the capacitor after the switch is closed. (iii) What is the current in the resistor 10.0 s after the switch is closed?

**Question 17 (10 marks)**

- (a) **(5 Marks)** A person holds a mirror in front of their face. The mirror is concave with a radius of curvature of 30.0 cm. It is positioned so that the (upright) image of the person's face is 2.0 times the size of their face. How far is the mirror being held from their face?
- (b) **(5 Marks)** The image of the coin in the magnifying glass (a thin converging lens) in Figure 8 is magnified by a factor of two. It is an upright, virtual image. The distance from the coin to the lens is 5.0 cm. Determine the focal length of the lens.



Figure 8: The image of a coin in a magnifying glass.