Physics 161 - Second Midterm Exam
Dr Monahan and Prof Kloet
November 20, 2016

Your name sticker with exam code

Turn off and put away cell phones!

1. The exam will last from 1:40 pm to 3:00 pm. Use a #2 pencil to make entries on the blue answer sheet. ENTER the following ID information NOW, BEFORE THE EXAM STARTS (see points 2-5 below).

2. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.

3. Under STUDENT # enter your 9-digit student ID.

4. Under COURSE enter 161, under SEC enter your section number (see label).

5. Under CODE enter the exam code given above.

6. During the exam, you may use pencils, a calculator, and one handwritten 8.5 x 11 inch sheet with formulas and notes, without attachments.

7. There are 15 multiple-choice questions on the exam. For each question mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the end of the exam, hand in the answer sheet and the cover page. Retain this question paper for future reference and study.

8. When you are asked to open the exam, make sure that your copy contains all 15 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.

9. Please SIGN the cover sheet under your name sticker and have your student ID ready to show to the proctor during the exam.

Good Luck!
Natural Constants, etc.

- $N_A = 6.02 \times 10^{23}$ mol$^{-1}$
- $k_B = 1.38 \times 10^{-23}$ J/K
- $R = 8.31$ J/mol/K
- $G = 6.67 \times 10^{-11}$ N m$^2$/kg$^2$
- $g = 9.8$ m/s$^2$
- $m_{\text{earth}} = 5.98 \times 10^{24}$ kg
- $R_{\text{earth}} = 6.38 \times 10^6$ m
- $T_C = T_K - 273.15$
- 1 ATM = $1.013 \times 10^5$ N/m$^2$
- $c_{\text{water}} = 4186$ J/kg$^\circ$C
- $c_{\text{ice}} = 2090$ J/kg$^\circ$C
- $L_{\text{ice}} = 3.33 \times 10^5$ J/kg
- $\rho_{\text{water}} = 1000$ kg/m$^3$
- $\rho_{\text{ice}} = 917$ kg/m$^3$
- 1 m$^3$ = 1000 liter
1. A block of wood has density 0.50 \text{g/cm}^3 and mass 1000 g. It floats in a container of oil (the oil's density is 0.75 \text{g/cm}^3). What volume of oil does the wood displace?

   a) 2000 cm\(^3\)
   b) 1333 cm\(^3\)
   c) 750 cm\(^3\)
   d) 500 cm\(^3\)
   e) 250 cm\(^3\)

2. A cylinder contains two moles of a monoatomic gas at a temperature of 9.1 °C. The gas undergoes an expansion at a constant pressure of 1.00 atm to six times its original volume. Calculate the work done on the gas during the expansion.

   a) 35.2 kJ
   b) -35.2 kJ
   c) 23.4 kJ
   d) -23.4 kJ
   e) 16.3 kJ

3. A monoatomic gas follows the path from state C to state A in the P-V diagram as shown in the figure. The pressure and volume are respectively C (1 atm, 1 liter) and A (3 atm, 1 liter). The temperature at A is 300°K. How much heat is added or extracted from the gas as it follows the path C-A?

   a) 101 J of heat is extracted
   b) 101 J of heat is added
   c) 304 J of heat is extracted
   d) 304 J of heat is added
   e) 203 J of heat is extracted
4. A beaker is filled to the rim with water. An ice cube of 50 gram is lowered into the beaker. How much water will spill out, if any?
   a) none
   b) about 50 \( \text{cm}^3 \)
   c) about 10 \( \text{cm}^3 \)
   d) it depends on the volume of the water in the beaker
   e) about 55 \( \text{cm}^3 \)

5. The flow rate of blood through the average human aorta is about 90 \( \text{cm}^3/s \). The cross section of the aorta is circular and its radius is 1.1 \( \text{cm} \). What is the speed of the blood through the aorta?
   a) 12 \( \text{cm/s} \)
   b) 26 \( \text{cm/s} \)
   c) 31 \( \text{cm/s} \)
   d) 24 \( \text{cm/s} \)
   e) 9.1 \( \text{cm/s} \)

6. A 14500 \( \text{N} \) car on a hydraulic lift rests on a cylinder with a piston of radius 0.20 \( \text{m} \). If a connecting cylinder with a piston of 0.030 \( \text{m} \) radius is driven by compressed air, what force must be applied to the smaller piston in order to lift the car?
   a) 326 \( \text{N} \)
   b) 644 \( \text{N} \)
   c) 826 \( \text{N} \)
   d) 266 \( \text{N} \)
   e) 14500 \( \text{N} \)

7. It takes 2.5 minutes to fill a gas tank with 50 liters of gasoline. If the pump nozzle is 2.0 \( \text{cm} \) in radius, what is the average speed of the gasoline as it leaves the nozzle? Assume that the nozzle has a circular cross section.
   a) 0.27 \( \text{m/s} \)
   b) 0.03 \( \text{m/s} \)
   c) 1.59 \( \text{m/s} \)
   d) 0.13 \( \text{m/s} \)
   e) 2.0 \( \text{m/s} \)
8. Two moles of an ideal gas at 3 atm and 14°C are heated up to 150°C. If the volume is held constant during this heating, what is the final pressure?

- a) 4.4 atm
- b) 2.0 atm
- c) 12.2 atm
- d) 5.5 atm
- e) 32.1 atm

\[ \frac{P_1}{T_1} = \frac{P_2}{T_2} \]

\[ P_2 = \frac{3}{2} \frac{423.15}{150 + 273.15} = 4.42 \text{ atm} \]

9. Two samples of the same ideal gas have the same mass and are kept at equal pressure in spherical containers. One container has radius \( r = 1 \text{ m} \) and the other container has a radius of 0.9 m. If the temperature of the gas in the smaller container is 25°C, what is the temperature of the gas in the larger container?

- a) 34.3 °C
- b) 135.8 °C
- c) 12.2 °C
- d) 94.9 °C
- e) 217.0 °C

\[ \frac{V_1}{V_2} = \left( \frac{R_1}{R_2} \right)^{3/2} \Rightarrow \frac{T_1}{T_2} = \left( \frac{0.9}{1} \right)^{1.5} = 0.32 \]

\[ T_1 = 25°C \times 0.32 = 8.0°C \]

10. Let the total mechanical energy of a harmonic spring-mass oscillator be \( E = 135.83 \text{ J} \) and the maximum displacement \( A \). When the displacement is \( A/4 \), what is the kinetic energy?

- a) \( E/16 \)
- b) \( E/2 \)
- c) \( 3E/4 \)
- d) \( 15E/16 \)
- e) \( E \)

\[ E = \frac{1}{2} k x^2 + \frac{1}{2} m v^2 = \frac{1}{2} k A^2 \]

11. The distance between two successive minima of a transverse wave is 2.76 m. Five crests of the wave pass a given point along the direction of travel every 14.0 s. Find the frequency of the wave.

- a) 0.36 Hz
- b) 0.99 Hz
- c) 2.80 Hz
- d) 1.97 Hz
- e) 0.49 Hz

\[ \lambda = 2.76 \text{ m} \]

\[ ST = 14.0 \Rightarrow T = 2.8 \Rightarrow f = \frac{1}{T} = 0.357 \text{ Hz} \]
12. How much heat is extracted from the environment if a 2 kg block of ice at 0 °C melts in a room at room temperature T = 20 °C. At the end of the process both room and meltwater are at room temperature.
   a) 333 kJ  
   b) 666 kJ  
   c) 710 kJ  
   d) 750 kJ  
   e) 833 kJ

\[ Q_1 = 2.33 \times 10^5 \text{ J} \]
\[ Q_2 = 2.48 \times 10^5 \text{ J} \]
\[ Q_1 + Q_2 = 833 \times 10^5 \text{ J} \]

13. The acceleration due to gravity on the surface of Mars is 3.73 m/s². What is the ratio of the period of a simple pendulum of length 0.5 m on Mars to the period of the same pendulum on the surface of the Earth?
   a) 2.63  
   b) 2.30  
   c) 1.62  
   d) 0.62  
   e) 0.38

\[ T_{Mars} = \sqrt{\frac{g_{Earth}}{g_{Mars}}} = \sqrt{\frac{9.8}{3.73}} = 1.62 \]

14. A mass is attached to a spring, with spring constant 150 N/m, so that the whole system lies horizontally on a frictionless table. If the mass oscillates with an amplitude of 2.7 cm and has a maximum speed of 0.2 m/s, what is its mass?
   a) 0.050 kg  
   b) 0.136 kg  
   c) 5.46 kg  
   d) 2.33 kg  
   e) 2.73 kg

\[ E = \frac{1}{2} k x^2 + \frac{1}{2} m v^2 = \frac{1}{2} k x^2 + 0 = \frac{1}{2} k v_{max}^2 \]
\[ \frac{1}{2} k A^2 = \frac{1}{2} m v_{max}^2 \]
\[ m = \frac{150 \times 0.02^2}{0.2^2} = 2.73 \text{ kg} \]

15. The root-mean-square (rms) speed of a sample of hydrogen gas, H₂, is 1.2×10^8 m/s. The mass of a hydrogen molecule is 3.34×10⁻²³ kg. Assuming the hydrogen gas behaves as an ideal gas, what is the temperature of the gas sample?
   a) 14.0 K  
   b) 58.1 K  
   c) 82.2 K  
   d) 116 K  
   e) 348 K

\[ \frac{1}{2} m v^2 = \frac{3}{2} R T \Rightarrow T = \frac{m v^2}{3 R} \]
\[ T = \frac{3.34 \times 10^{-22} \times 1200^2}{3 \times 1.38 \times 10^{-23}} = 116.17 \text{ K} \]