Physics 161 - Final Exam  
Dr Monahan and Prof Kloet  
December 20, 2016

Your name sticker with exam code  

Turn off and put away cell phones!

1. The exam will last from 12:00 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 two handwritten 8.5 x 11 inch sheets with formulas and notes, without attachments.

7. There are 30 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 30 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.

**BATHROOM RULE: ONE PERSON AT A TIME**

Good Luck!
Natural Constants, etc.

- $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
- $k_B = 1.38 \times 10^{-23} \text{ J/K}$
- $R = 8.31 \text{ J/mol/K}$
- $G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$, and $g = 9.8 \text{ m/s}^2$
- $e = 1.602 \times 10^{-19} \text{ C}$
- $m_e = 9.11 \times 10^{-31} \text{ kg}$
- $m_p = 1.67 \times 10^{-27} \text{ kg}$
- $k_e = 8.99 \times 10^9 \text{ N m}^2/\text{C}^2$
- $\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N m}^2$ (permittivity of free space)
- $c = 3.0 \times 10^8 \text{ m/s}$
- 1 atm = $1.013 \times 10^5 \text{ Pa}$, and 1 m$^3$ = 1000 liter
- $m_{\text{earth}} = 5.98 \times 10^{24} \text{ kg}$, and $R_{\text{earth}} = 6.38 \times 10^6 \text{ m}$
- $T_C = T_K - 273.15$
- $c_{\text{water}} = 4186 \text{ J/kg/}^\circ\text{C}$
- $c_{\text{ice}} = 2090 \text{ J/kg/}^\circ\text{C}$, and $L_{\text{ice}} = 3.33 \times 10^5 \text{ J/kg}$
- $\rho_{\text{water}} = 1000 \text{ kg/m}^3$, and $\rho_{\text{ice}} = 917 \text{ kg/m}^3$
- $\log(ab) = \log(a) + \log(b)$, and $\log(a/b) = \log(a) - \log(b)$
1. When a light bulb is connected to a 12 V battery, it dissipates a power $P$. When a second, identical light bulb is connected in series with the first light bulb to the battery, what is the power dissipated in each bulb?
   a) $2P$
   b) $P$
   c) $P/4$
   d) $P/2$
   e) $P/16$

2. Three observers, A, B, and C are listening to a moving source of sound. The diagram below shows the location of the wavecrests of the moving source with respect to the three observers. Which of the following is true?
   a) The wavefronts move faster at A than at B and C
   b) The wavefronts move faster at C than at A and B
   c) The frequency of the sound heard by A is highest
   d) The frequency of the sound heard by B is highest
   e) The frequency of the sound heard by C is highest

3. At rest, a car’s horn has a frequency of 400 Hz. The horn is sounded while the car is at rest. A bicyclist, moving towards the car, hears a frequency of 415 Hz. What is the speed of the bicycle? (The speed of sound in air is 343 m/s).
   a) 7.5 m/s
   b) 9.8 m/s
   c) 11.7 m/s
   d) 12.9 m/s
   e) 15.0 m/s
4. Three capacitors with capacitance $A = 6 \mu F$, $B = 9 \mu F$ and $C = 12 \mu F$, are connected to a 12 V battery, as shown in the Figure. What is the voltage drop across capacitor A?

- a) 9.33 V
- b) 5.53 V
- c) 4.47 V
- d) 2.23 V
- e) 0.42 V

5. Consider a collection of charges in a given region. If the electric potential at a certain point in the region is zero, which of the following statements must be true?

a) The electric field is zero at that point
b) The electric potential energy is a minimum at that point
c) There is no net charge in the region
d) Some charges in the region are positive and some are negative
e) The charges have the same sign and are symmetrically arranged around a given point.

6. A string is 20.0 cm long and has a mass of 2.3 g. A wave travels at 3.0 m/s along the string. A second string has the same length, but half the mass of the first. If the two strings are under the same tension, what is the speed of the wave along the second string?

- a) 6.00 m/s
- b) 4.24 m/s
- c) 2.25 m/s
- d) 2.12 m/s
- e) 1.50 m/s
7. An object is placed 5.5 cm in front of a concave mirror. The focal length of the mirror is 13 cm. Where is the image formed?
   a) 9.53 cm in front of the mirror
   b) 9.53 cm behind the mirror
   c) 3.86 cm in front of the mirror
   d) 3.86 cm behind the mirror
   e) 35.7 cm behind the mirror

8. An object is placed 10.25 cm to the left of a converging lens with focal length of 8.5 cm. What is the magnification?
   a) 0.829
   b) -0.206
   c) -4.86
   d) 0.206
   e) 4.86

9. The electric flux through an imaginary spherical surface with radius 60 cm centered on a point charge + q is $6.6 \times 10^{-6} \, Nm^2/C$. What is the electric field on the spherical surface?
   a) $1.75 \times 10^{-6} \, N/C$ inwards
   b) $1.75 \times 10^{-6} \, N/C$ outwards
   c) $1.46 \times 10^{-6} \, N/C$ outwards
   d) $1.46 \times 10^{-6} \, N/C$ inwards
   e) $7.29 \times 10^{-6} \, N/C$ outwards

10. A sample of radon gas has a mass of 3.5 g initially. After 2.7 days, the sample contains 1.84 g. What is the half-life of radon?
    a) 0.49 days
    b) 0.71 days
    c) 1.42 days
    d) 3.83 days
    e) 2.91 days
11. Three electric charges are placed along the x-axis. Charge \(-Q\) is placed at \(x = 0\ m\), charge \(+Q\) is placed at \(x = 2\ m\), charge \(-Q\) is placed at \(x = 4\ m\). What are the electric potentials at \(x = 1\ m\) and at \(x = 3\ m\) respectively?

- a) \(\frac{1}{3}k_eQ\) and \(\frac{1}{3}k_eQ\)
- b) \(-\frac{1}{3}k_eQ\) and \(\frac{1}{3}k_eQ\)
- c) \(\frac{1}{3}k_eQ\) and \(-\frac{1}{3}k_eQ\)
- d) \(-\frac{1}{3}k_eQ\) and \(-\frac{1}{3}k_eQ\)
- e) none of the other answers

12. Jupiter has a mean radius that is 11 times larger than the Earth’s mean radius and a mass 315 times larger than the mass of the Earth. What is the acceleration due to gravity at Jupiter’s surface?

- a) 25.51 m/s\(^2\)
- b) 0.34 m/s\(^2\)
- c) 2.60 m/s\(^2\)
- d) 3.76 m/s\(^2\)
- e) 281 m/s\(^2\)

13. Titan is a moon of Saturn, orbiting with a semimajor axis of 1,222,000 km and a period of 16 days. What is the mass of Saturn?

- a) \(5.7 \times 10^{26}\) kg
- b) \(5.7 \times 10^{17}\) kg
- c) \(7.8 \times 10^{22}\) kg
- d) \(1.4 \times 10^{25}\) kg
- e) \(3.2 \times 10^{28}\) kg

14. Three resistors, 6 \(\Omega\), 9 \(\Omega\) and 12 \(\Omega\) are coupled to a 12 V battery as in the Figure. How much current flows through the 12 \(\Omega\) resistor?

- a) 0.26 A
- b) 0.33 A
- c) 1.08 A
- d) 0.62 A
- e) 0.46 A
15. By what amount does the sound intensity level decrease when the distance to the source triples?
   a) 1.9 dB  
   b) 3 dB  
   c) 8 dB  
   d) 9.5 dB  
   e) 0.11 dB

16. The voltage across a parallel plate capacitor is $V$. The magnitude of the charge on each plate is $Q$. The electric field between the plates is $E$. The stored electric energy in the capacitor is $W$. If the voltage is doubled the new values are respectively
   a) $2Q$, $4E$, $4W$  
   b) $2Q$, $2E$, $2W$  
   c) $2Q$, $2E$, $4W$  
   d) $2Q$, $E$, $2W$  
   e) $2Q$, $E$, $4W$

17. A beam of light in air is incident on the surface of a rectangular block of clear plastic ($n = 1.48$). If the velocity of the beam before it enters the plastic is $3.00 \times 10^8 \text{m/s}$, what is its velocity inside the block?
   a) $3.00 \times 10^8 \text{m/s}$  
   b) $1.37 \times 10^8 \text{m/s}$  
   c) $2.03 \times 10^8 \text{m/s}$  
   d) $2.47 \times 10^8 \text{m/s}$  
   e) $1.56 \times 10^8 \text{m/s}$

18. Assume the Earth is a perfect sphere of radius $R = 6.38 \times 10^6 \text{m}$. Because of the Earth's rotation your weight at the Equator and at the South Pole differ by
   a) less than 0.1 %  
   b) more than 0.1 % but less than 0.2 %  
   c) more than 0.2 % but less than 0.3 %  
   d) more than 0.3 % but less than 0.4 %  
   e) more than 0.4 %
19. Three electric charges are placed along the x-axis. Charge \(-Q\) is placed at \(x = 0\ m\), charge \(+Q\) is placed at \(x = 2\ m\), charge \(-Q\) is placed at \(x = 4\ m\). What are the magnitude and direction of the electric field at \(x = 1\ m\) and at \(x = 3\ m\) respectively? (Use convention for direction: towards \(x=0\) is left, away from \(x=0\) is right)

\[
\begin{align*}
\text{a) } & \quad \frac{17}{9} k_e Q \text{ to the left and } \frac{17}{9} k_e Q \text{ to the right} \\
\text{b) } & \quad \frac{17}{9} k_e Q \text{ to the left and } \frac{17}{9} k_e Q \text{ to the left} \\
\text{c) } & \quad \frac{17}{9} k_e Q \text{ to the right and } \frac{17}{9} k_e Q \text{ to the left} \\
\text{d) } & \quad \frac{17}{9} k_e Q \text{ to the right and } \frac{17}{9} k_e Q \text{ to the right} \\
\text{e) none of the other answers}
\end{align*}
\]

20. Let the total mechanical energy of a spring/mass system be \(E_0\) and the maximum displacement be \(x_0\). When the displacement is \(-x_0/3\), what is the kinetic energy?

\[
\begin{align*}
\text{a) } & \quad 2E_0/3 \\
\text{b) } & \quad 4E_0/9 \\
\text{c) } & \quad 8E_0/3 \\
\text{d) } & \quad E_0/9 \\
\text{e) none of the other answers}
\end{align*}
\]

21. May stands on top of a 18 m high overpass and throws a tennis ball to her friend June who stands on the street below, 9 m away from the base of the overpass. May throws the ball at an angle of 60° below the horizontal. At what speed does May have to throw the ball?

\[
\begin{align*}
\text{a) } & \quad 6.4 \text{ m/s} \\
\text{b) } & \quad 13.0 \text{ m/s} \\
\text{c) } & \quad 11.5 \text{ m/s} \\
\text{d) } & \quad 20.8 \text{ m/s} \\
\text{e) } & \quad 25.7 \text{ m/s}
\end{align*}
\]
22. A monoatomic gas executes a cycle in the P-V diagram as shown from A (3 atm, 1 liter) to B (1 atm, 2 liter) to C (1 atm, 1 liter) to A. The temperature at A is 300°K. How much heat is added or extracted from the gas during one cycle A-B-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

23. The volume of an ideal gas changes from 0.40 m³ to 0.58 m³ while the pressure remains constant at 51000 Pa. What work is done on the gas by the environment?

- a) −9180 J
- b) 9180 J
- c) −20400 J
- d) 20400 J
- e) −29580 J

24. For a tube with both ends open, the fundamental frequency is 500 Hz. What is the fundamental frequency for this tube when one end is closed and one end is open?

- a) 167 Hz
- b) 125 Hz
- c) 1000 Hz
- d) 750 Hz
- e) 250 Hz

25. 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
26. 0.5 kg of ice at -10 °C is placed in 2.0 kg of water at 18 °C. After the system reaches equilibrium, how much ice is left?
   a) 0.000 kg
   b) 0.015 kg
   c) 0.028 kg
   d) 0.079 kg
   e) 0.047 kg

27. In a nuclear decay reaction $^{14}_{6}C \rightarrow ^{A}_{Z}X + e^- + \bar{\nu}$, the final nucleus has $(A, Z)$ equal to
   a) (14, 6)
   b) (13, 5)
   c) (10, 4)
   d) (15, 5)
   e) (14, 7)

28. 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 cm³
   c) about 10 cm³
   d) it depends on the volume of the water in the beaker
   e) about 55 cm³

29. A 60.0 kg object is placed in an elevator accelerating upwards with 1 m/s². The force exerted by the floor of the elevator onto the object is
   a) 60 N
   b) 648 N
   c) 600 N
   d) 588 N
   e) 528 N
30. A 250 kg box is placed at rest at point A on a plane that is inclined 20° to the horizontal. The box slides down the frictionless plane and when it reaches point B on the plane, it has a speed of 4 m/s. What is the distance between A and B?

- a) 0.28 m
- b) 0.82 m
- c) 1.55 m
- d) 2.39 m
- e) 2.84 m