Note: This mock test consists of questions covered in Physics 117. This test is not comprehensive. The problems on this test were compiled by your Structured Study Session (SSS) peer mentors, and not your professors, and are based on problems from old exams, found on the website http://physics.usask.ca/~bzulkosk/phys117/index.html. (Note: The figures and diagrams have also been taken from old tests.) **This mock test should not be viewed as a ‘preview’ of the actual test, and you should not rely solely on it for your test preparation.**

In particular, please note that the actual Phys 117 midterm will include a Part B section with a new format (i.e. multiple choice ‘scratch pad’ format). The format of the Part B section of the mock midterm will be the same as past exams in Phys 117 (i.e. long answer, show your work).

**Phys 117 Structured Study Session Information**

Mondays 5:30-6:50pm – Room 102 in the Murray Library (Jason)
Tuesdays 4:00-5:20pm – Room 102 in the Murray Library (Michael v.)
Fridays 1:00-2:20pm – Room G3 in the Murray Library (Michael D.)

Student Learning Services (SLS) is a unit of the University Library that offers learning support to students. You can find information about the following services for students on the SLS website (http://library.usask.ca/studentlearning):

- Study Skills
- Writing Help
- Math & Stats Help
- Structured Study Sessions for Phys 117 and Bio 120
- Workshops on topics such as tech help, library skills, and more

Also, visit the University Library website (http://library.usask.ca) for information on other library services and programs.
Part A – Multiple Choice

1. Two objects of exactly the same size and shape, one made of wood and the other made of steel, are placed in a container of water. The wood object floats and the steel object sinks to the bottom of the container. Which one of the following statements is TRUE?

(A) Both objects experience the same magnitude of buoyant force.
(B) The buoyant force on the wood object is directed upward and the buoyant force on the steel object is directed downward.
(C) The buoyant force on both objects is directed downward.
(D) The magnitude of the buoyant force on the wood object is greater than on the steel object.
(E) The magnitude of the buoyant force on the steel object is greater than on the wood object

2. Which one of the following statements regarding Stress and Strain is FALSE?

(A) Stress is the force per unit area causing a deformation; Strain is a measure of the amount of the deformation.
(B) Provided the stress does not exceed the elastic limit of the material, a solid object returns to its original length when the stress is removed.
(C) A solid object will break as soon as the stress exceeds the elastic limit of the material.
(D) The maximum stress that a non-ductile object can withstand without breaking is called the ultimate strength.
(E) If the tensile or compressive stress exceeds the proportional limit then the strain is no longer proportional to the stress.

3. A viscous fluid is flowing steadily through a pipe of radius r. Suppose you replace it by two parallel pipes, each of radius ½ r, but the same length as the original pipe. If the pressure difference between the ends of these two pipes is the same as for the original pipe, what is the total rate of flow in the two pipes compared to the original flow rate, $Q_1$?

(A) 1/8 $Q_1$
(B) 1/4 $Q_1$
(C) 1/2 $Q_1$
(D) $Q_1$
(E) 2 $Q_1$

4. Let h be the depth below the surface of the ocean at which the absolute pressure is three times atmospheric pressure (i.e. $3P_{atm}$). The pressure at a depth of ½ h below the surface of the ocean is

(A) 1.5 $P_{atm}$  (B) 2 $P_{atm}$  (C) 3 $P_{atm}$  (D) 3.5 $P_{atm}$  (E) 4 $P_{atm}$
5. Two speakers, separated by a distance d, are producing coherent sound waves that are in phase at a point P that is the same distance from each speaker. The wavelength of the sound being produced is \( \lambda \). Point Q is a distance \( r_1 \) from speaker 1 and a distance \( r_2 \) from speaker 2. Which one of the following conditions will ensure that the sound waves from the speakers interfere **destructively** at Q?

(A) \(|r_2 - r_1| = 2d\)
(B) \(|r_2 - r_1| = d\)
(C) \(|r_2 - r_1| = \frac{1}{2} d\)
(D) \(|r_2 - r_1| = \lambda\)
(E) \(|r_2 - r_1| = \frac{1}{2} \lambda\)

6. Which one of the following statements concerning simple harmonic motion (SHM) is TRUE?

(A) SHM can occur near any point of equilibrium (point of stable or unstable equilibrium).
(B) SHM occurs for any force that tends to restore equilibrium.
(C) SHM occurs for any restoring force whose magnitude is proportional to the square of displacement from a point of stable equilibrium.
(D) SHM occurs for any restoring force whose magnitude is proportional to the magnitude of the displacement from a point of stable equilibrium.
(E) SHM occurs for any restoring force whose magnitude varies inversely with the magnitude of the displacement from a point of stable equilibrium.

7. As you travel down the highway in your car, an ambulance moves away from you at a high speed, sounding its siren at a frequency of 400 Hz. Which one of the following statements is true?

(A) You and the ambulance driver both hear a frequency greater than 400 Hz.
(B) You and the ambulance driver both hear a frequency less than 400 Hz.
(C) You and the ambulance driver both hear a frequency of 400 Hz.
(D) You hear a frequency greater than 400 Hz, whereas the ambulance driver hears a frequency of 400 Hz.
(E) You hear a frequency less than 400 Hz, whereas the ambulance driver hears a frequency of 400 Hz.

8. A tube open at both ends has a fundamental resonant frequency of f. If you close one end of the tube, the fundamental resonant frequency becomes...

(A) f  
(B) 2f  
(C) \( \frac{1}{2} f \)  
(D) \( \frac{3}{2} f \)  
(E) 4f
9. In a certain time interval, light travels 6.20 km in a vacuum. During the same time interval, light travels only 3.40 km in a liquid. The refractive index of the liquid is

(A) 0.55  (B) 0.62  (C) 1.33  (D) 1.69  (E) 1.82

10. Which region in the EM spectrum has the lowest frequency?

(A) red light  (B) violet light  (C) X-rays  (D) gamma rays  (E) radio waves

11. Light travelling through the air (refractive index = 1.00) is incident at angle $\beta$ with respect to the surface normal on glass with a refractive index of $n_g$. From the glass, it passes through a layer of water, refractive index $n_w$. What is the angle of refraction of the light with respect to the surface normal as it passes from the glass to the water?

(A) $\sin^{-1}\left(\frac{\sin\beta}{n_{air}n_{water}}\right)$  (B) $\sin^{-1}\left(\frac{\sin\beta}{n_{water}}\right)$

(C) $\sin^{-1}\left(\frac{n_{air}\sin\beta}{n_{glass}n_{water}}\right)$  (D) $\sin^{-1}\left(\frac{n_{glass}\sin\beta}{n_{water}}\right)$

(E) $\sin^{-1}\left(\frac{\sin\beta}{n_{air}}\right)$

12. You wish to design a simple magnifier that has the largest possible angular magnification. You have a choice of two converging lenses, the focal length of lens 1 is less than the focal length of lens 2. Which one of the following setups will satisfy your design goal?

(A) Use lens 1 and place the object at the near point of the person using the magnifier.
(B) Use lens 2 and place the object at the near point of the person using the magnifier.
(C) Use lens 1 and place the object so that the image formed by the lens is at the near point of the person using the magnifier.
(D) Use lens 2 and place the object so that the image formed by the lens is at the near point of the person using the magnifier.
(E) Use lens 1 and place the object so that the image formed by the lens is at the far point of the person using the magnifier.

13. A compound microscope is made from a combination of two lenses. Which one of the following statements is TRUE?

(A) Both lenses form real images.
(B) Both lenses form virtual images.
(C) The lens closest to the object forms a virtual image; the other lens forms a real image.
(D) The lens closest to the object forms a real image; the other lens forms a virtual image.
14. In a Young’s double-slit interference apparatus, by what factor is the distance between adjacent bright and dark fringes changed when the separation between the slits is doubled?
(A) $\frac{1}{4}$  (B) $\frac{1}{2}$  (C) 1  (D) 2  (E) 4

15. A girl has a near point of 1.5 m. Which one of the following statements is correct?
(A) She has normal vision.
(B) She is myopic (nearsighted) and requires diverging lenses to correct her vision.
(C) She is myopic (nearsighted) and requires converging lenses to correct her vision.
(D) She is hyperopic (farsighted) and requires diverging lenses to correct her vision.
(E) She is hyperopic (farsighted) and requires converging lenses to correct her vision.

16. Three resistors, each of different value, are used in a circuit with a power source supplying 12 V. For which of the following resistor combinations is the total power supplied by the source the greatest?
(A) all three resistors in series
(B) all three resistors in parallel
(C) two of the resistors in parallel with the third resistor in series with the parallel pair
(D) two of the resistors in series with the third resistor in parallel with the series pair
(E) This cannot be found until it is known which resistor is in series with the parallel pair.

17. Which one of the following statements correctly describes the situation when an object is in thermal equilibrium with its surroundings?
(A) The object no longer absorbs thermal radiation from the surroundings, but it continues to emit thermal radiation at a constant rate.
(B) The object no longer absorbs thermal radiation from the surroundings, but it continues to emit thermal radiation at a rate that is dependent on the temperature of the object.
(C) The object emits thermal radiation at the same rate that it absorbs thermal radiation from its surroundings.
(D) The object no longer emits thermal radiation, but it continues to absorb thermal radiation from its surroundings at a constant rate.
(E) The object no longer emits thermal radiation, but it continues to absorb thermal radiation from its surroundings at a rate that is dependent on the temperature of the surroundings.

18. A window conducts energy from the inside of a house to the cold outdoors at a rate of $P$. What is the rate of energy conduction through a window that has half the area and is half as thick?
(A) $\frac{1}{4}P$  (B) $\frac{1}{2}P$  (C) $P$  (D) $2P$  (E) $4P$
19. When a hole is drilled in a metal plate, the drill bit and plate become hot due to friction between the drill bit and the plate. What happens to the diameter of the hole after the plate cools to room temperature?

(A) It decreases.
(B) It increases.
(C) It remains the same.
(D) The answer depends on whether the initial temperature of the metal plate is above 0°C.
(E) The answer depends on the size of the hole.

20. The binding energy of a nucleus is equal to...

(A) the energy needed to remove one of the nucleons.
(B) the average energy with which any nucleon is bound in the nucleus.
(C) the energy needed to separate all the nucleons from each other.
(D) the mass of the nucleus times \( c^2 \).
(E) the energy released from a fusion reaction.

21. What is the symbol for the nuclide with 46 protons and 92 neutrons?

(A) \(^{96}_{46}Pu\)  
(B) \(^{138}_{92}U\)  
(C) \(^{138}_{46}Pu\)  
(D) \(^{46}_{92}U\)  
(E) \(^{46}_{138}Pu\)

22. The activity of a radioactive sample (with a single radioactive nuclide) decreases to one eighth its initial value in a time interval of 96 days. What is the half-life of the radioactive nuclide?

(A) 8 days  
(B) 12 days  
(C) 16 days  
(D) 24 days  
(E) 32 days

23. Radium-226 (Ra 226 88) undergoes alpha decay to form Radon (Rn). What are the atomic number and mass number of the isotope of radon produced?

(A) \( Z = 90, A = 220 \)  
(B) \( Z = 86, A = 222 \)  
(C) \( Z = 89, A = 226 \)  
(D) \( Z = 87, A = 226 \)  
(E) \( Z = 88, A = 222 \)

24. Which one of the following statements regarding the atomic nucleus is FALSE?

(A) The nucleus is approximately spherical.
(B) The nuclear radius is much less than the atomic radius.
(C) The nuclear radius is proportional to the cube root of the mass number.
(D) The mass density of the nucleus is the same as the mass density of the atom.
(E) The total energy of the nucleus is less than the energy of the individual protons and neutrons.
25. Isotopes of the same element have:

(A) the same number of neutrons but different numbers of protons.
(B) the same number of electrons but different numbers of protons.
(C) the same number of neutrons but different numbers of electrons.
(D) the same number of protons but different numbers of neutrons.
(E) the same number of protons but different numbers of electrons.

End of Part A

Part B – Long Answer Questions

B1. For the purposes of this question, you may assume that air is an ideal, incompressible fluid. Air is flowing into a Venturi meter (see diagram). The narrow section of the pipe at point A has a radius that is 1/2 of the radius of the larger section of the pipe at point B. You may assume that the density of the air is constant. The U-shaped tube is filled with water.

(a) If the air speed at B is X, how fast is the air moving at point A, in terms of X?

(b) The density of air is 1.29 kg/m³ and the density of water is 1.00 x 10³ kg/m³. The difference in the height, h, of the water in the arms of the manometer (the U-shaped tube) is 1.75 cm. Calculate the numerical value of X. If you did not obtain an answer for (a), use a value of 2X.

(c) The radius of the larger section of pipe is 5.00 cm. Calculate the volume flow rate (in m³/s) of air through the pipe. If you did not obtain an answer for (b), use a value of 4.50 m/s.
B2. An underground train station is connected to the outside through a tunnel. Some machinery is producing noise at a frequency dominated by 62.00 Hz and a second machine operating nearby has a strong noise peak at 58.00 Hz. The resulting beat is greatly amplified by the tunnel through resonance. That is, the beat frequency corresponds to one of the resonance modes of the tunnel. This makes a very annoying low frequency vibration for the passengers awaiting the next train.

(a) Consider the tunnel to be an air pipe open at both ends and derive an expression for the possible natural (resonance) frequencies.

(b) Calculate the frequency of the beats produced by the machinery.

(c) You know that the tunnel is at least 100 m long, and knowing that the speed of sound was 344 m/s on that particular day, you figured that you could get a better estimate for the length of the tunnel, given the resonance condition. From the beat frequency and the knowledge that the tunnel is behaving like an air pipe open at both ends and is somewhat longer than 100 m, calculate which harmonic of the tunnel (air pipe) is being excited (i.e. which harmonic corresponds to the beat frequency) and calculate a more precise estimate for the length of the tunnel. If you did not obtain an answer for (b), use a value of 5 Hz.

B3. There are 5620 lines per centimeter in a grating that is used with violet light whose wavelength is 471 nm. A flat observation screen is located at a distance of 0.750 m from the grating.

(a) Calculate the separation between consecutive slits of the grating.
(b) Calculate the angular location of the first order maximum of the violet light. (If you did not obtain a value for (a), use 1.50 × 10⁻⁶ m.)

(c) Calculate the order that corresponds to the maximum (bright fringe) with the largest angular location.

(d) Calculate the minimum width that the screen must have so that the centres of all the principal maxima formed on either side of the central maximum fall on the screen.

B4. The distance from the lens to the retina in John’s eyes is 2.00 cm.

(a) Assume that John can form focused images at distances between 28.0 cm and infinity. Calculate the upper and lower limits of the focal lengths of John’s eyes.

(b) John looks at an object 2.00 m tall that is a distance of 23.5 metres away. Calculate the size of the image on his retina.

(c) Thirty years later, John can no longer focus on objects closer than 75.4 cm. Calculate the refractive power (in diopters) of the contact lenses that will restore John’s range of vision to 28.0 cm to infinity.
B5. Polonium, $^{210}_{84}Po$ (atomic mass = 209.982848 u), undergoes alpha decay to become Lead, $^{206}_{82}Pb$ (atomic mass = 205.974440 u). The atomic mass of the alpha particle is 4.002603 u.

(a) Calculate the approximate volume of the Polonium nucleus.

(b) Calculate the energy released in the alpha decay of Polonium-210.

(c) The half-life of Uranium-238 is 4.47 $\times$ 10^9 years. Calculate the age of a rock specimen that contains 60.0% of its original number of Uranium-238 atoms.

B6. One of the nuclides produced in a fission power reactor is $^{131}_{53}I$. $^{131}_{53}I$ has a half-life of 8.03 days. $^{131}_{53}I$ is not produced directly by the neutron-induced fission of $^{235}_{92}U$ but rather is a product of the decays of other nuclides.

(a) Consider the following neutron-induced fission reaction: $n + {}^{235}_{92}U \rightarrow {}^{131}_{50}Sn + {}^{A}_ZX + 3n$

Calculate the values of $A$ and $Z$ for the reaction product $X$. 
(b) Consider the generic $\beta^-$ decay reaction shown below. P refers to the parent nucleus and D refers to the daughter nucleus. Fill-in-the-blanks to show the atomic number and mass number of the daughter nucleus D, in terms of Z and A. Also fill-in-the-blanks to show the third decay product.

$$\frac{A}{Z} P \rightarrow _Z^A D + \beta^- + _\_$$

(c) After a series of $\beta^-$ decays, $^{131}_{50}$Sn has transformed into $^{131}_{53}$I. Starting with $^{131}_{50}$Sn, how many $\beta^-$ decays must occur for $^{131}_{53}$I to be formed?

(d) The Nuclear Safety Commission has determined that intake of drinking water is to be restricted if the $^{131}_{53}$I activity in a sample exceeds 300 becquerel/kg. On March 20, 2011 the activity of $^{131}_{53}$I in a sample obtained from a water supply near the damaged Fukushima Daiichi reactors in Japan was measured to be 965 Becquerel/kg. Calculate the number of days required for the activity of $^{131}_{53}$I in the sample to decrease to 300 Becquerel/kg

END OF EXAMINATION