Physics 117 Mock Final - Answers
Wednesday, April 5, 2017 * 4:30pm – Room 107 Physics Building *

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, 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 final 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 final will be the same as past exams in Phys 117 (i.e. long answer, show your work).

If you think you’ve found an error, please email phys_sss@usask.ca (thanks!).

Note: Please omit question A16 (the concepts dealt with in this question are not covered in Phys 117). Our apologies for including this question by mistake.

### Answers to Part A (multiple-choice questions)

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### Answers to Part B (long-answer questions)

B1.  a) \(v_A = 4x\)  
     b) \(x = 4.21 \text{ m/s}\)  
     c) \(Q = 3.31 \times 10^{-2} \text{ m}^3/\text{s}\)

B2.  a) \(f_n = n \left( \frac{v}{2L} \right)\)  
     b) \(f_b = 4.00 \text{ Hz}\)  
     c) \(n = 3, L = 129 \text{ m}\)

B3.  a) \(d = 1.78 \times 10^3 \text{ nm}\)  
     b) \(\theta = 15.3^\circ\)  
     c) \(m_{\text{max}} = 3\)  
     d) minimum width = 1.96 m

B4.  a) 1.87 cm to 2.00 cm  
     b) \(|h'| = 0.170 \text{ cm}\)  
     c) \(P = +2.25D\)

B5.  a) \(V = 1.52 \times 10^{-42} \text{ m}^3\)  
     b) \(\Delta E = 5.41 \text{ MeV}\)  
     c) \(t = 3.30 \times 10^4 \text{ years}\)

B6.  a) \(A = 102, Z = 42\)  
     b) \(\frac{1}{2}P \rightarrow z^1D + \beta^- + \bar{\nu}\) or \(\frac{1}{2}P \rightarrow z^1D + -^0\beta^- + \bar{\nu}\)  
     c) 3 \(\beta\)-decay  
     d) \(t = 13.5 \text{ days}\)

More detailed solutions for selected questions can be found on the following pages.

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 (open during the final exam period! http://library.usask.ca/math-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 – detailed solutions

1. \[ R = \rho \text{ fluid}, \quad V = \text{ fluid}, \quad g \quad \text{Steel displaces more fluid} \]
   
   Ans: \( \circ \quad E \)

2. Ans: \( C \) as past elastic limit, we deform the object; not broken.

3. \[ Q = \frac{\pi}{8} \frac{\Delta P L}{\eta} \cdot r^4 \]

   For single new pipe, \( Q_2 = \frac{1}{16} Q_1 \) as \( r_2 = \frac{1}{2} r_1 \)

   Combined \( Q = 2Q_2 = \frac{1}{8} Q_1 \)

   Ans: \( \circ \quad A \)

4. \[ 3P_{atm} = P_{atm} + p \cdot g \cdot h \Rightarrow p \cdot g \cdot h = 2P_{atm} \quad h = \frac{2P_{atm}}{g} \]

   \[ h = \frac{1}{2} h \Rightarrow P_{\frac{1}{2}h} = P_{atm} + P_{atm} = 2P_{atm} \]

   Ans: \( B \)
5. 

Destructive: \[ |r_2 - r_1| = \left( n - \frac{1}{2} \right) \lambda \]

Ans: E 

6. 

\[ \bar{F} = -k \vec{x} \quad \therefore F \propto x \]

Ans: D 

7. 

Ans: E. Source is moving away from you: force < f source.
Source and ambulance move as one: force = source.

8. 

\[ L = \frac{1}{2} \lambda \]
\[ \lambda = 2L \]
\[ f_1 = \frac{v}{\lambda} = \frac{v}{2L} \]
\[ L = \frac{1}{4} \lambda \]
\[ \lambda = 4L \rightarrow f_2 = \frac{v}{4L} \]
\[ f_2 = \frac{1}{2} f_1 \]

Ans: C 

Answers will be posted on the Structured Study Session web page: http://library.usask.ca/sss
9. \[ \begin{align*}
\Delta x_0 &= 6.20 \text{ km} \quad v_0 = c \\
\Delta x &= 3.40 \text{ km} \quad v = ? \\
\eta &= \frac{c}{v}, \quad \Delta x = vt \Rightarrow v = \frac{\Delta x}{t}, \quad t = \frac{\Delta x_0}{c} \\
& \therefore v = \frac{\Delta x}{\Delta x_0/c} = \frac{\Delta x \cdot c}{\Delta x_0} \Rightarrow \eta = \frac{c}{\left(\frac{\Delta x \cdot c}{\Delta x_0}\right)} = \frac{\Delta x_0}{\Delta x} \\
& \therefore \eta = \frac{\Delta x_0}{\Delta x} = \frac{6.20 \text{ km}}{3.40 \text{ km}} = 1.82 \quad \therefore \boxed{E}
\end{align*} \]

10. Remember the EM spectrum:
\[ \lambda: \text{gamma rays} < \text{x-rays} < \text{UV} < \text{violet} < \text{red} \]
\[ \text{red} < \text{infrared} < \text{microwaves} < \text{radio} \]
but \( \lambda \) and \( f \) inversely related, so:
\[ f: \text{radio} < \text{microwaves} < \text{infrared} < \text{red} \]
\[ \text{red} < \text{violet} < \text{UV} < \text{x-rays} < \text{gamma rays} \]
\[ \therefore \boxed{E} \]

11. \[ \begin{align*}
\eta_a \sin \beta &= \eta_g \sin \Theta, \quad \eta_g \sin \Theta &= \eta_w \sin \phi \\
& \therefore \eta_a \sin \beta = \eta_w \sin \phi \\
& \therefore \phi = \sin^{-1} \left( \frac{\eta_a \sin \beta}{\eta_w} \right) \\
\eta_a &= 1.00 \quad \therefore \phi = \sin^{-1} \left( \frac{\sin \beta}{\eta_w} \right) \\
\end{align*} \]
12. Remember that the largest possible magnification occurs when the image is at the near point. To find which lens to use:

\[ m = \frac{N}{P}, \quad \frac{1}{P} + \frac{1}{\varphi} = \frac{1}{f} \Rightarrow \frac{1}{P} = \frac{1}{f} - \frac{1}{\varphi} \]

\[ m = N\left(\frac{1}{f} - \frac{1}{\varphi}\right) \varphi \text{ is at the near point and virtual, therefore:} \]

\[ m = N\left(\frac{1}{f} - \frac{1}{\varphi}\right) = N\left(\frac{1}{f} + \frac{1}{N}\right) = \frac{N}{f} + \frac{N}{N} = \frac{N}{f} + 1 \]

Therefore \( m \) is at a maximum when \( f \) is smallest, therefore use lens C.

13. Remember that in a compound microscope:
- The objective lens forms a real, enlarged image which becomes the object for the eyepiece lens.
- The eyepiece lens forms a virtual, enlarged final image.

14. \( m \lambda = 2 \sin \Theta \Rightarrow \sin \Theta = \frac{m \lambda}{2} \]

By the small angle approximation, \( \sin \Theta \approx \tan \Theta = \frac{y}{L} \)

\[ \Rightarrow \frac{y}{L} = \frac{m \lambda}{2} \Rightarrow y \propto \frac{m \lambda}{L} \quad , \quad d_2 = 2d \]

\[ \Rightarrow y_2 = \frac{m \lambda}{L_2} = \frac{m \lambda}{2d} \Rightarrow y_2 \approx \frac{1}{2} y \quad \therefore B \]

15. The normal near point is considered to be 25 cm. 1.5 m > 25 cm therefore the girl is farsighted. Hyperopia is corrected with a converging lens. E
16. Omit this question (it was selected in error).

17. Not A) since then the object would be cooling

Not B) since the object would also be cooling

Since then the energy of the object would stay constant and therefore so would the temperature.

18. General formula:

\[ P = \frac{k_w A \Delta T}{L} \]

If original area \(A\) and original thickness \(L\), then the new area \(\frac{A}{2}\) and new thickness \(\frac{L}{2}\). The new rate of energy conduction is then:

\[ P_{\text{new}} = k_w \left( \frac{A}{2} \right) \left( \frac{\Delta T}{\frac{L}{2}} \right) \]

This simplifies to:

\[ P_{\text{new}} = k_w \left( \frac{A}{2} \right) \left( \frac{2}{L} \right) (\Delta T) = k_w A \frac{\Delta T}{L} \]

So \(P_{\text{new}} = P\). Answer: (C)

19. \( \Delta T = \alpha T \Delta T \)

20. The Binding Energy is the energy used to hold together a nucleus. One could think conversely to see it as the energy needed to pull apart a nucleus.
21.  

\[ {\text{Atoms}} \rightarrow \text{Palladium} \]

\[ \text{Pd} \]

\[ \text{Atomic weight} = 138 \]

\[ \text{Atomic number} = 46 \]

22. We first solve for \( \lambda \).

\[ R_i = \lambda N_i \]

\[ R_f = \lambda N_f \]

\[ R_f = \frac{1}{B} R_i \]

Setting the two equations for \( R_f \) equal to each other, and replacing \( R_i \) with \( \lambda N_i \), gives:

\[ \frac{1}{B} R_i = \lambda N_f \]

\[ \frac{1}{B} \lambda N_i = \lambda N_f \]

\[ \frac{1}{B} N_i = N_f \]

Recall that:

\[ N_f = N_i e^{-\lambda t} \]

So we replace \( N_f \) with this formula and solve for \( \lambda \):
\[ \frac{1}{b} N_i = N_i e^{-\lambda t} \]
\[ b = e^{-\lambda t} \]
\[ \ln \left( \frac{1}{8} \right) = -\lambda t \]
\[ -\frac{\ln \left( \frac{1}{8} \right)}{t} = 2 \]

Substitute the given value of \( t \) (96 days):
\[ t = 96 \text{ days} \]
\[ \frac{-\ln \left( \frac{1}{8} \right)}{96 \text{ days}} = 2 \]

Recall the half-life formula:
\[ T_{\frac{1}{2}} = \frac{\ln 2}{\lambda} \]

Substituting the value of \( \lambda \) found earlier, and simplifying, gives:
\[ T_{\frac{1}{2}} = \frac{\ln 2}{\lambda} = \frac{\ln 2}{\ln \left( \frac{1}{8} \right) - \frac{96}{\ln \left( \frac{1}{8} \right)}} = (\ln 2) \left( \frac{-96}{\ln \left( \frac{1}{8} \right)} \right) = 32 \text{ days} \]

Answer is (E).
23.
\[ ^{236}Ra \rightarrow ^{234}Rn + \frac{1}{2} \alpha \]
\[ 236 - 2 = 234 \text{ protons} \]
\[ 234 - 4 = 230 \text{ mass number} \]
(3)

24.
(0) is False since the atom is much much larger than the nucleus and mostly made of empty space.

25.
Isotopes are atoms that have:
- same number of protons + electrons
- different mass number

(0)
Part B – detailed solutions

B1. a)

Logic: \( v_A \) has smaller radius so \( v_A > v_B \)

Continuity of Flow:

\[
\frac{\pi}{4} r_A^2 \cdot v_A = \frac{\pi}{4} r_B^2 \cdot v_B
\]

\[
\frac{\pi}{4} r_A^2 \cdot \frac{v_B}{\sqrt{\gamma}} \cdot x = \frac{\pi}{4} r_B^2 \cdot \frac{v_A}{\sqrt{\gamma}} \cdot x
\]

\[v_A = \frac{4}{\sqrt{\gamma}} x\]

b)

\( \rho_{water} = 1.29 \text{ kg/l} \), \( \gamma = 1 \times 10^3 \text{ kg/m}^3 \)

\( h = 1.75 \text{ cm} \). Calculate \( x \)

Bernoulli’s Principle:

\[
P_A + \frac{1}{2} \rho \cdot v_A^2 + \rho \cdot g \cdot y_A = P_B + \frac{1}{2} \rho \cdot v_B^2 + \rho \cdot g \cdot y_B
\]

Note: \( y_A = y_B \)

\[P_B = P_A + \rho \cdot w \cdot g \cdot h\]

\[
\frac{P_A}{\rho} + \frac{1}{2} \rho \left( \frac{4}{\sqrt{\gamma}} x \right)^2 = \frac{P_A}{\rho} + \rho \cdot w \cdot g \cdot h + \frac{1}{2} \rho \cdot x^2
\]

\[
2 \left( \frac{1}{2} \rho \cdot 16 x^2 \right) = \left( \rho \cdot w \cdot g \cdot h + \frac{1}{2} \rho \cdot x^2 \right)^2
\]

\[x = \frac{4.21 \text{ m/s}}{\sqrt{15}}
\]
B2.

(a) \[ L = \frac{1}{2} \lambda \]
\[ \lambda = 2L \]
\[ f = \frac{v}{\lambda} = \frac{v}{2L} \]

Next Resonance:
\[ L = 2 \left( \frac{1}{2} \lambda \right) \]
\[ \lambda = 2L \]
\[ f = \frac{v}{\lambda} = \frac{v}{2L} \]

\[ f_2 = 2f_1 \]
So in general \[ f_n = n \left( \frac{v}{2L} \right) \]

(b) \[ f_b = \left| f_2 - f_1 \right| = \left| 62.0 \text{ Hz} - 58.0 \text{ Hz} \right| = 4.00 \text{ Hz} \]

(c) \[ v = 344 \text{ m/s} \]
\[ L \approx 100 \text{ m} \] (but larger than 100m)

Best frequency is producing a harmonic

First use approximation of \( L = 100 \text{ m} \) to find harmonic. (we found in any case)
\[ f_n = n \left( \frac{v}{2L} \right) \Rightarrow n = \frac{f_n \cdot 2L}{v} = \frac{(400 \text{ Hz})(2)(100 \text{ m})}{344 \text{ m/s}} \]
\[ n = 2.3 \text{, but } n \text{ is an integer : round up} \]

Harmonic = 3

\[ f_n = n \left( \frac{v}{2L} \right) \Rightarrow L = \frac{n \cdot v}{2f_n} = \frac{3.344 \text{ m/s}}{2 \cdot 400 \text{ Hz}} \]
\[ L = 129 \text{ m} \]

Answers will be posted on the Structured Study Session web page: http://library.usask.ca/sss
B3.

a) 

\[ n = 5620 \text{ lines/cm} \quad d = \frac{1}{n} \]

\[ d = \frac{1 \text{ cm}}{5620 \text{ lines}} \Rightarrow d = 1.78 \times 10^{-4} \text{ cm} = 1.78 \times 10^3 \text{ nm} \]

\[ d = 1.78 \times 10^3 \text{ nm} \]

(b) Note: “invsin” used below is the same thing as “\(\sin^{-1}\)”. 

\[ d \sin \theta_{\text{bright}} = m \lambda, \quad m = 1 \]

\[ \theta = \sin^{-1} \left( m \frac{\lambda}{d} \right) \Rightarrow \theta = \sin^{-1} \left( \frac{1(4.71 \text{ nm})}{1780 \text{ nm}} \right) \]

\[ \theta = 15.3^\circ \]

(c) 

\[ d \sin \theta_{\text{bright}} = m \lambda \quad \Rightarrow \quad m = \frac{d \sin \theta}{\lambda} \quad \text{(for integer } m) \]

\[ \theta_{\text{max}} = 90^\circ \Rightarrow m_{\text{max}} = \frac{d \sin (90^\circ)}{\lambda} \Rightarrow m_{\text{max}} = \frac{d}{\lambda} \]

\[ m_{\text{max}} = \frac{(1780 \text{ nm})}{(4.71 \text{ nm})} = 3.78, \quad \text{largest integer } \leq 3.78 \text{ is } 3. \]

\[ m_{\text{max}} = 3 \]

d) 

\[ \tan \theta = \frac{y}{x} \Rightarrow y = x \tan \theta \]

\[ \theta = \sin^{-1} \left( \frac{m \lambda}{d} \right) \Rightarrow y = x \tan \left( \sin^{-1} \left( \frac{m \lambda}{d} \right) \right) \]

\[ \therefore 2y = 2x \tan \left( \sin^{-1} \left( \frac{3 \lambda}{d} \right) \right) = 2(0.75 \text{ m}) \tan \left[ \sin^{-1} \left( \frac{3(4.71 \text{ nm})}{1780 \text{ nm}} \right) \right] \]

\[ \therefore \text{minimum width is: } 1.96 \text{ m} \]
B4.

a) \[ q = 2.00 \text{ cm} \quad p_n = 28.0 \text{ cm} \]

\[
\frac{1}{p_n} + \frac{1}{q} = \frac{1}{f_n} \quad \Rightarrow \quad f_n = \left( \frac{1}{p_n} + \frac{1}{q} \right)^{-1}
\]

\[
f_n = \left( \frac{1}{28.0 \text{ cm}} + \frac{1}{2.00 \text{ cm}} \right)^{-1} \quad \Rightarrow \quad f_n = 1.87 \text{ cm}
\]

\[ p_f = \infty \quad \Rightarrow \quad \frac{1}{p_f} = 0 \quad \Rightarrow \quad \frac{1}{q} = \frac{1}{p_f} \quad \Rightarrow \quad p_f = q = 2.00 \text{ cm} \]

\[ ;, \text{ upper and lower limits of } f: 2.00 \text{ cm to } 1.87 \text{ cm} \]

b) \[ p = 23.5 \text{ m} = 2350 \text{ cm} \]

\[ q = 2.00 \text{ cm} \]

\[ h = 2.00 \text{ m} = 200 \text{ cm} \]

\[ M = \frac{h'}{h} = -\frac{q}{p} \quad \Rightarrow \quad h' = -\frac{qh}{p} \]

\[ h' = \frac{(200 \text{ cm})(200 \text{ cm})}{(2350 \text{ cm})} \quad \Rightarrow \quad |h'| = 0.170 \text{ cm} \]

c) Contact lens needs to create an image at \( q \) (negative, since it is virtual). When an object is at \( p \).

\[ p = 0.280 \text{ m} \quad q' = -0.754 \text{ m} \]

\[
p = \frac{1}{f} = \frac{1}{p} + \frac{1}{l} \quad \Rightarrow \quad p = \frac{1}{(0.280 \text{ m})} - \frac{1}{(0.754 \text{ m})}
\]

\[ p = +2.25 \text{ D} \]
B5.

a)  
\[ r = 5 \times 10^{-3} \text{ m} \]
\[ V = \frac{4}{3} \pi r^3 = \frac{4}{3} \pi (5 \times 10^{-3} \text{ m})^3 = 1.52 \times 10^{-6} \text{ m}^3 \]

b)  
\[ \Delta E = \Delta m c^2 = (209.9828 - 205.97441 - 4.0026) \text{ MeV} = 9.9315 \text{ MeV} \]

\[ \Delta E = 5.411 \text{ MeV} \]

c)  
\[ T_{1/2} = \frac{\ln 2}{\lambda} \]
\[ \lambda = \frac{\ln 2}{T_{1/2}} = \frac{\ln 2}{4.37 \times 10^{10} \text{ yr}} = 1.55 \times 10^{-10} \text{ yr}^{-1} \]
\[ N = N_0 e^{-\lambda t} \]
\[ \frac{N}{N_0} = 0.600 = e^{-\lambda t} \]
\[ \ln(0.600) = -\lambda t \]
\[ t = \frac{\ln(0.600)}{-\lambda} = 3.30 \times 10^{9} \text{ yr} \]
B6. 

a) 

\[ 1 + 235 = 131 + A + 3 \quad A = 102 \]

\[ 0 + 92 = 50 + z + 0 \quad z = 42 \]

b) 

\[ A \rho \rightarrow A^0 D + ^{-1}\beta^- + J \]

\[ Z \quad Z + 1 \]

c) 

3 \beta-decay

Answer to d) is on the next page.
d)

\[ R = 2N \quad N = N_0 e^{\frac{t}{T}} \]

\[ R = R_0 e^{-\frac{t}{T}} \]

\[ T_{1/2} = \frac{\ln 2}{\lambda} \]

\[ \lambda = \frac{\ln 2}{T_{1/2}} \]

\[ R = R_0 e^{-\frac{\ln 2 t}{T_{1/2}}} \]

\[ \ln \left( \frac{R}{R_0} \right) = -\frac{\ln 2 t}{T_{1/2}} \]

\[ t = -\frac{T_{1/2}}{\ln 2} \ln \left( \frac{R}{R_0} \right) \]

\[ t = -\frac{8.03 d}{0.693} \ln \left( \frac{300}{465} \right) = 13.5 \text{ d.} \]

End of Part B – good luck with your finals!