Physics 117 Mock Midterm - Answers
Sunday, February 12, 2017 * 1:30pm – Room 241 Arts 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 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).

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

Answers to Part A (multiple-choice questions)

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Answers to Part B (long-answer questions)

B1. a) 52.2 m/s   b) 2.67 × 10^4 Pa   c) 4.35 kg/s

B2. a) 8.01 × 10^{-4}   b) 8.01 × 10^3 N   c) 5.00 × 10^{-5} m^2   d) No, the cable has not been stretched beyond its elastic limit. Stress = \( \frac{F}{A} = \frac{8.01 \times 10^3 N}{5.00 \times 10^{-5} m^2} = 1.6 \times 10^8 Pa < 2.50 \times 10^8 Pa \)

B3. a) \( f = \frac{v}{2L} \) or \( f = n \left( \frac{v}{2L} \right) \)   b) 4.00 Hz   c) \( L = 129 \) m

B4. a) 7.90 kg   b) 2.57 m/s   c) 0.437 s

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

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 Physics Building (Michael D.)*

*The time and location of Michael D.’s session may change after the February Reading Week break. Please consult the SSS webpage (http://library.usask.ca/sss) for details.
Part A – detailed solutions

1. Remember Pascal’s Principle: A change in pressure applied to a confined fluid is transmitted to every point of the fluid and its container.

2. \[ F_r = 6\pi \eta r v \]
   \[ w = mg \]
   Falling at terminal speed therefore \( \Sigma F_y = 0 \)

3. \[
P_h = P_{atm} + \rho gh = 2P_{atm} \Rightarrow \rho gh = 2P_{atm} - P_{atm} = P_{atm}
\]
\[
P_{2h} = P_{atm} + \rho g (2h) = P_{atm} + 2(\rho gh) = P_{atm} + 2(P_{atm}) = 3P_{atm}
\]

4. \[
A_A \nu_A = A_B \nu_B, \quad A = \pi r^2 = \pi \left( \frac{d}{2} \right)^2 = \frac{\pi d^2}{4} \Rightarrow \nu_A = \frac{\pi \frac{d^2}{4}}{\nu} = \frac{\pi d^2}{4} \nu
\]
\[
\therefore \nu_A = \frac{d^2}{4} \nu
\]
\[
\nu_A = \frac{d^2}{4} \nu = \frac{\nu_B}{4} = \frac{\nu_B}{v_B} = v_A v_B
\]

5. Remember: \( B = \rho_{\text{fluid}} \text{ fluid} g \)
   System is in equilibrium.
   \[
   \Sigma F_{wy} = B_w - T - W_w = 0
   \]
   \[
   \Sigma F_{sy} = B_T + T - W_s = 0 \Rightarrow T = W_s - B_T \therefore T < W_s
   \]
6. 
\[ l = \frac{3}{2} \lambda \]
\[ \lambda = \frac{2}{3} l \]

7. 
\[ I \sim \frac{I}{R^2} = \frac{l}{2\lambda} - \frac{1}{\lambda} \]
\[ \frac{I}{l} \sim B \]

8. Answer is (B)

\[ |r_1 - r_2| = (n + \frac{1}{2}) \lambda \]
\[ = \frac{1}{2} \lambda \]
\[ r_2 = 1 \]
\[ r_1 = 2 + \frac{1}{2} \lambda \]

9. 
\[ A_{\text{max}} = \frac{2.5 \times 10^{-10}}{m} \]
\[ \omega = 3127 \]

\[ N_{\text{eff}} = A \]  
Since \( y = A \sin(\omega t) \)
\[ A_{\text{max}} = \sqrt{\left(2.5 \times 10^{-10}\right)^2 \times (5.2 \tau)^2} \approx 3 \times 10^{-9} \text{ m} \]

Answers will be posted on the Structured Study Session web page: http://library.usask.ca/sss
10. We know the car hears its own frequency of 440 Hz then either B or C

\[ f_D = f_S \left( \frac{V + V_0}{\sqrt{1 - V_0/V_s}} \right) \]

Sign convention

\[ V_s + \quad \text{if moving towards } V_s \]
\[ -V_s \quad \text{if moving away} \]

then new equation is

\[ f_D = f_S \left( \frac{V + V_0}{\sqrt{1 + 2V_0/V_s}} \right) \]

\[ V_s = \frac{1}{2} V_0 \]

\[ f_D = f_S \left( \frac{V + V_0}{\sqrt{1 + 2V_0/V_s}} \right) \quad \text{if fraction } < 1 \]

. then the man hears a lower frequency

B)
11. \[ T_1 = 10^\circ C, \quad T_2 = 20^\circ C \]

\[ v = 83.1 \text{ m/s} \sqrt{\frac{T}{273K}} \]

where \( T \) is in Kelvin

\[ T_1 = 288K, \quad T_2 > T_1 \quad \Rightarrow \quad v_2 > v_1 \]

\[ T_2 = 298K \]

[ANS: IS]

12. Power is constant

\[ \frac{P_1}{A_1} = \frac{I_1}{\frac{A_1}{A_2} = \frac{P_2}{A_2}} \]

\[ \frac{I_1}{I_2} = \frac{A_2}{A_1} = \frac{4}{1} \]

[ANS: A]

13. \[ \frac{\lambda}{2}, \quad \frac{\lambda}{4} \]

\[ L = \frac{\lambda}{2}, \quad \frac{200 \text{ cm}}{5} = 40 \text{cm} \]

[ANS: D]

14. "Distance varies by a full \( \lambda \); constructive interference\n
\[ I = \frac{P}{A} \quad \text{smaller distance from you has larger} \]

[ANS: A]
15. 

\[ V = \frac{T}{\mu} = \frac{T}{\mu_0} \]

\[ V_2 = 2V_1 \]

\[ V_1 = \frac{T}{\mu_0} = \frac{T}{\mu_0} = \frac{1}{2} \]

\[ V_2 = \frac{1}{2} \]

ANS. B

16. All EM waves travel through a vacuum at the same speed, c, but frequencies and wavelengths vary. Electric and magnetic fields are perpendicular to each other and to the direction of wave propagation.

End of Part A
Part B – detailed solutions

B1. a)

\[ \frac{\Delta V}{\iota} = \text{Area} \Rightarrow \text{Area} = \frac{\Delta V}{\iota} \cdot \frac{1}{\pi R^2} \]

\[ \text{Area} = \frac{(4.10 \times 10^{-3} \text{ m}^3/\iota)}{\pi (5.00 \times 10^{-3} \text{ m})^2} \Rightarrow \text{Area} = 52.2 \text{ m}^2/\iota \]

\[ \Rightarrow \frac{\Delta V}{\iota} = 52.2 \text{ m}^2/\iota < (a) \]

B1 b)

\[ \frac{\Delta V}{\iota} = \frac{\pi R^4 (P_1 - P_2)}{8 \eta L} \]

\[ \Delta P = P_1 - P_2 \Rightarrow \frac{\Delta V}{\iota} = \frac{\pi R^4 \Delta P}{8 \eta L} \]

\[ \Rightarrow \Delta P = \frac{(4.10 \times 10^{-3} \text{ m}^3/\iota)^2}{\pi (5.00 \times 10^{-3} \text{ m})^4} \times 8 \times (4.00 \times 10^{-3} \text{ Pa} \cdot \iota) \times (0.400 \text{ m}) \]

\[ \Delta P = 2.67 \times 10^4 \text{ Pa} \Rightarrow (b) \]

c)

\[ \frac{\Delta m}{\Delta \iota} = \rho \frac{\Delta V}{\iota} \text{ check: } \frac{kg}{s} = \frac{kg}{m^3} \times \frac{m^3}{s} = \frac{kg}{s} \]

\[ \frac{\Delta m}{\Delta \iota} = (1060 \text{ kg/m}^3) \times (4.10 \times 10^{-3} \text{ m}^3/\iota) = 4.346 \text{ kg/s} \]

\[ \Rightarrow \frac{\Delta m}{\Delta \iota} = 4.35 \text{ kg/s} \leftarrow (c) \]
B2. a)

\[ x = \frac{1}{2}l, \quad \cos \theta = \frac{x}{l} \Rightarrow r = \frac{x}{\cos \theta}, \quad L_{\text{new}} = 2r = 2x \]

Strain = \( \frac{\Delta L}{L_0} = \frac{L_{\text{new}} - l}{l} \),

\[ L_{\text{new}} = \frac{2x}{\cos \theta} = 2 \left( \frac{2l}{3} \right) = \frac{l}{\cos \theta} \]

\[ \text{Strain} = \frac{1}{\cos (0.0400 \text{ rad})} - 1 = 8.005 \times 34 \times 10^{-4} \]

\[ \text{Strain} = 8.01 \times 10^{-4} \]

(b)

\[ \Sigma F_y = 0 = T \sin \theta + T \sin \theta - W \]

\[ T \sin \theta = W \]

\[ T = \frac{W}{2 \sin \theta} \]

\[ T = \frac{(641 \text{ N})}{2 \sin (0.0400 \text{ rad})} = 8.01 \times 10^3 \text{ N} \]

\[ T = 8.01 \times 10^3 \text{ N} \]

(continued over)

B2. c)
d)  

\[
\frac{F}{A} = \frac{Y \Delta L}{L_0}, \quad F = T, \quad \frac{(\Delta L)}{L_0} = \text{strain}
\]

\[
\frac{T}{A} = \frac{Y \cdot \text{strain}}{A} = \frac{T}{Y \cdot \text{strain}} = \frac{(8.01 \times 10^3 \text{N})}{(2.00 \times 10^8 \text{Pa})(8.01 \times 10^{-4})}
\]

\[A = 5.00 \times 10^{-5} \text{ m}^2 \qquad (c)\]

\[P_{\text{max}} = 2.50 \times 10^8 \text{Pa}\]

\[P = \frac{F}{A} = \frac{T}{A} \Rightarrow P = \frac{(8.01 \times 10^3 \text{N})}{(5.00 \times 10^{-5} \text{m}^2)} = 1.602 \times 10^8 \text{Pa}\]

\[1.60 \times 10^8 \text{Pa} < 2.50 \times 10^8 \text{Pa} \quad \therefore \quad \text{NO} \quad (\alpha)\]

B3.

a) Look for a pattern. Start with \(f_1\):

I.e. \(\lambda_1 = 2L\). Since \(v = f\lambda\), we can solve for the frequency \(f_1\): \(f_1 = \frac{v}{\lambda_1}\). Substituting for \(\lambda_1\) gives: \(f_1 = \frac{v}{2L}\).

Next resonance mode \((f_2)\):

Or: \(L = 2 \left(\frac{1}{2}\lambda\right) = \lambda\). Using the same equations as above, we get \(f_2 = \frac{v}{\lambda_2} = \frac{v}{L}\).

(Continued over)

Next resonance mode \((f_3)\):
\[ \lambda_3 = \frac{2}{3} L \text{ so } f_3 = \frac{v}{\lambda_3} = \frac{v}{(\frac{2}{3}) L} = \frac{3}{2} \frac{v}{L}. \]

So: \( f_1 = 1 \left( \frac{v}{2L} \right), f_2 = 2 \left( \frac{v}{2L} \right), f_3 = 3 \left( \frac{v}{2L} \right), \) and so on. So \( f_n = n \left( \frac{v}{2L} \right) \) or, equivalently, \( f = \frac{nv}{2L} \).

(b)

\[ \begin{align*}
\frac{f_1}{f_2} &= 1 \frac{v}{2L} - \frac{v}{2L} \\
\frac{f_3}{f_2} &= 1 \frac{3.800 \text{ Hz}}{62.00 \text{ Hz}} = 0.610 \text{ Hz} \\
\frac{f_3}{f_2} &= 4.00 \text{ Hz}
\end{align*} \]

(c)

\[ \begin{align*}
v &= 244 \text{ m/s} \\
L &= 100 \text{ m} \\
v &= \frac{\lambda}{L}
\end{align*} \]

Solving for \( n \) gives: \( n = \frac{f_n (2L)}{v} \). Use this formula and \( L = 100 \text{ m}, f_n = 4 \text{ Hz}, v = 344 \text{ m/s} \) to get an estimate for \( n \):

\[ \begin{align*}
n &\geq \left( \frac{4 \text{ Hz}}{244 \text{ m/s}} \right) \frac{(2)(100 \text{ m})}{344} = 2.3
\end{align*} \]

Since \( n \) has be an integer, take \( n = 3 \). (continued over)
B3 c) continued:
To find \( L \), solve \( f_n = n \left( \frac{v}{2L} \right) \) for \( L \) and use \( n = 3 \) along with the values for \( f_n \) and \( v = 344 \text{ m/s} \).

\[
L = \frac{nv}{2f_n} = \frac{3(344 \text{ m/s})}{2(4 \text{ Hz})} = 129 \text{ m}
\]

B4.

a)

\[
E_t = 247.05 \text{ J}, \quad x_{max} = 0.240 \text{ m}, \quad v_{max} = 6.244 \text{ m/s}
\]

\[
\frac{v_{max}}{\text{no friction}} \quad PE_x = \frac{1}{2} k x^2
\]

\[
K E = \frac{1}{2} m v^2
\]

\( m = (2)(47.05) \)

\[
(3.45 \text{ m/s})^2\]

\[
m = 7.90 \text{ kg}
\]

b)

\( v \) at 0.160 m = \( d_x \), so \( d_x < x_{max} \)

at \( d_x \) we have both forms of energy

Conservation of energy:

\[
PE_{Ex} + KE_{Ex} = E_t
\]

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

We need to find \( k \). Consider the \( PE_{max} \) situation:

\[
E_t = PE_{max} = \frac{1}{2} k x_{max}^2
\]

Solving for \( k \) gives: \( k = \frac{2E_t}{x_{max}^2} = \frac{2(47.05)}{(0.240 \text{ m})^2} \) (we can leave \( k \) like this, or evaluate it). (continued over)

Substituting this value of \( k \) into the equation for conservation of energy when \( x = 0.160 \text{ m} \) gives:

Answers will be posted on the Structured Study Session web page: http://library.usask.ca/sss
\[ \frac{1}{2} \cdot 2(47.0 \text{ J}) \cdot (0.160 \text{ m})^2 + \frac{1}{2} \cdot (7.90 \text{ kg})v^2 = 47.0 \text{ J} \]

Solving for \( v \) gives:

\[ v = \sqrt{\frac{2}{7.90} \left( 47.0 - \frac{47.0 \text{ J}}{(0.240 \text{ m})^2 \cdot (0.160 \text{ m})^2} \right)} \approx 2.57 \text{ m/s} \]

c)

\[ \omega = \frac{2\pi}{T} \]

\[ T = \sqrt{\frac{m^2}{k}} \cdot 2\pi \]

\[ T = \sqrt{\frac{7.90}{1.63 \text{ N/m}}} \cdot 2\pi \]

\[ T = 0.437 \text{ s} \]

End of Part B

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.