Note: This mock test consists of questions covered in Physics 115. This test is not comprehensive. The problems on this test were compiled by your 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.

Students should also be aware that the real midterm exam will consist of 12 multiple choice questions and 4 long-answer questions in a ‘scratch card’ format. The mock midterm has 15 multiple choice questions and 4 long-answer questions in a ‘show your work’ format.

If you think you’ve found an error, please email the Phys 115 SSS team at phys_sss@usask.ca. Thanks!

Please ignore question A10 – this question is beyond the scope of the midterm.

Answers to Multiple Choice questions

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<thead>
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<th>C (omit)</th>
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Answers to Long-Answer questions

**B1.**
(a) $t = 3.49$ seconds  
(b) $v = 19.8 \, \text{m/s}$  
(c) $\Delta y = 11.8 \, \text{m}$

**B2.**
(a) See detailed solutions  
(b) $F = \frac{\mu_k mg}{\cos \theta - \mu_k \sin \theta}$

**B3.**
(a) $W_{nc} = -1.29 \times 10^3 J$  
(b) distance = $5.49 \times 10^{-2} \, \text{m}$  
(c) $|f_k| = 2.35 \times 10^4 \, \text{N}$

**B4.**
(a) $19.8 \, \text{m}$  
(b) $19.7 \, \text{m/s}$

Detailed solutions follow.

**Phys 115 Structured Study Session Information**

Mondays 5:30-6:50pm - Room G3 in the Murray Library (Jason)  
Tuesdays 2:30-3:50pm – Room G3 in the Physics Building (Michael)  
Thursdays 4:00-5:30pm – Room G3 in the Murray Library (Yen)  
Website: [http://library.usask.ca/sss](http://library.usask.ca/sss)
Part A – Multiple Choice Questions

1. A

\[ F = G \frac{m_1 m_2}{r^2} \]

force, unit in N = kg m s\(^{-2}\)

\[ N = G \frac{m_1 m_2}{r^2} \]

mass, unit of kg

\[ \frac{m_1 m_2}{r^2} = G \]

\[ G = \frac{m_1 m_2}{r^2} = m_1 m_2 \]

\[ m_1 m_2 = \frac{\text{m} \text{m}^{-1} \text{s}^{-2}}{r^2} \]

2. A

\[ \frac{R^2}{L} \]

\[ \frac{V_x}{L} \]

\[ \frac{V_y}{L} \]

\[ R = \frac{L}{C} \]

\[ L = \frac{(V_x)^2}{g} \]

\[ L = \frac{(V_y)^2}{g} \]

\[ L = \frac{(V_z)^2}{g} \]

Note: trig functions are unitless, so

\[ R = \frac{V_z}{g} \]

3. B

In equilibrium

\[ \sum \mathbf{F} = 0 \]

\[ \sum \mathbf{F}_x = 0 \]

\[ \sum \mathbf{F}_y = 0 \]

\[ -T_1 \cos \theta_1 + T_2 \cos \theta_2 = 0 \]

\[ T_1 \cos \theta_1 = T_2 \cos \theta_2 \]
4. C

\[ \vec{F} = 0 \Rightarrow \text{This means } \vec{a} = 0 \]
\[ \vec{a} = 0 \text{ means velocity is constant } \vec{v} \]
\[ \text{constant } \vec{v} \text{ corresponds with slope } = 0 \text{ on } \vec{v} \text{ vs. } t \text{ graph} \]
\[ \therefore \text{ sections } II \& IV \text{ correspond to condition of zero net force.} \]

5. C

5C both objects start with initial vertical velocity \( v_y = 0 \) at the exact same height

\[ \Delta y = v_y^2 + \frac{1}{2} a y^2 \]
\[ + \left( \sqrt{2 \Delta y / a y} \right) \text{ time to drop only} \]
\[ \text{depends on initial height } y, \text{ and acceleration } g \]
\[ \text{since both stones have same } v_y^2, y, \text{ and } g \text{ acts} \]
\[ \text{on both, both stones reach the bottom of the} \]
\[ \text{canyon at the same time.} \]
6. D

"negative velocity" means car is moving in the negative direction.

"positive acceleration" has the opposite sign to the velocity, which means the magnitude of the velocity is getting smaller. Speed is decreasing.

7. E

\[ \sum F = m a \]

\[ \sum F_x = m a \]

\[ \sum F_y = 0 \]

\[ n - w + F_y = 0 \]

\[ w = mg \]

\[ n - mg - P\sin\theta = 0 \]

\[ P_y = P\sin\theta \]

\[ n = mg + P\sin\theta \]

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

\[ \Sigma F_1 = m_1 a_1 \quad \Sigma F_2 = m_2 a_2 \]
\[ \Sigma F_{xx} = m_1 a_1 \quad \Sigma F_{xx} = m_2 a_2 \]

Since two blocks are moving together, they have the same acceleration.

\[ a_1 = a_2 \]

\[ T = m_1 a_1 \quad -T + F = m_2 a_2 \]
\[ a_1 = \frac{T}{m_1} \quad a_2 = \frac{F - T}{m_2} \]

\[ \left( \frac{m_2}{m_1} \right) \frac{T}{m_1} = \left( \frac{F - T}{m_2} \right) \]

Isolate \( T \)

\[ 7m_2 = (F - T)m_1 \]
\[ Tm_2 = Fm_1 - Tm_1 \]
\[ Tm_1 + Tm_2 = m_1 F \]
\[ T(m_1 + m_2) = m_1 F \]
\[ T = \left( \frac{m_1}{m_1 + m_2} \right) F \]

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

Let $m_2$ be the mass of the lightest projectile, so $m_1 > m_2$ and $m_3 > m_2$.

\[ KE_i = KE_{i2} = KE_{i3} \]

all with different PE

\[ PE_i = m_1gy_i \]
\[ PE_{i2} = m_2gy_{i2} \]
\[ PE_{i3} = m_3gy_{i3} \]

\[ KE_i + PE_i = KE_{i2} + PE_{i2} \]
\[ KE_i + PE_i = KE_{i3} + PE_{i3} \]

\[ D \text{ and height is zero} \]

\[ (m_1 - m_3)gy_i = \frac{1}{2} \left( m_1v_{1f}^2 - m_3v_{3f}^2 \right) \]

Then let's say $m_1 > m_3$

\[ \frac{1}{2} \left( m_1v_{1f}^2 - m_3v_{3f}^2 \right) > 0 \]

\[ m_1v_{1f}^2 > m_3v_{3f}^2 \]

\[ \sqrt{\frac{v_{1f}^2}{m_1}} \neq \sqrt{\frac{v_{2f}^2}{m_2}} \]

\[ \text{since} \quad \frac{m_3}{m_1} < 1 \]

\[ v_{1f}^2 < v_{2f}^2 \]

\[ \Rightarrow \quad \left| v_{1f} \right| < \left| v_{2f} \right| \]

Continued ...
Question 9, continued ...
So the speed of the projectile with mass \( m_1 \) is less than the speed of the projectile with mass \( m_2 \). That is, the speed of the lighter mass is greater than the speed of the heavier mass (because \( m_1 > m_2 \)).

A similar argument could be made for the projectile with mass \( m_3 \) (heavier when compared with the projectile with the lightest mass, \( m_2 \)). So the speed of the projectile with mass \( m_3 \) is less than the speed of the projectile with mass \( m_2 \). Overall, the projectile with the lightest (lowest) mass has the greatest speed of all the projectiles just as it impacts the ground. 

10. omit this question for now – it’s beyond the scope of the midterm

11. B

12. C (next page)
13. D
Let \( m_g \) = mass of golf ball, \( v_{gi} \) = initial velocity of the golf ball, \( h_i \) = initial height = 0, \( v_{gf} \) = final velocity of the golf ball = 0 (because its velocity will be zero when it reaches its maximum height), \( y_{g_{max}} \) = maximum height reached by the golf ball.

Energy is conserved, so \( KE_i + PE_i = KE_f + PE_f \) for each ball. Starting with the golf ball:

\[
\frac{1}{2} m_g v_{gi}^2 + m_g g(0) = \frac{1}{2} m_g (0)^2 + m_g g y_{g_{max}}
\]

Cancelling \( m_g \) from each side gives

\[
\frac{1}{2} v_{gi}^2 = m_g g y_{g_{max}}
\]

Solving for \( y_{g_{max}} \) gives \( y_{g_{max}} = \frac{1}{2} \frac{v_{gi}^2}{g} = \frac{v_{gi}^2}{2g} \). That is, the maximum height reached by the golf ball depends only on its initial velocity.

A similar calculation for the Ping-Pong ball gives \( y_{p_{max}} = \frac{1}{2} \frac{v_{pi}^2}{g} = \frac{v_{pi}^2}{2g} \).

Since \( v_{pi} = v_{gi} \) (the initial velocities of Ping-Pong ball and the golf ball are the same), they both reach the same maximum height. \( \square \)

14. D

Friction produces heat and sound, and the energy is used by friction, it cannot be recovered. Friction is a non-conservative force.

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

\[ W = \Delta KE = KE_f - KE_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \]
\[ W_{\text{down}} = \frac{1}{2}m(2v)^2 - \frac{1}{2}mv^2 = \frac{3}{2}mv^2 \]

End of Part A

Part B – Long Answer Questions

B1. (a)

\[ \vec{v}_i = 25.0 \text{ m/s} \]
\[ \theta = 35.0^\circ \]
\[ a_x = 0 \]
\[ a_y = -g \]

\[ v_{ix} = v_i \cos \theta \]
\[ v_{iy} = v_i \sin \theta \]

\[ x_f = 50.0 \text{ m} \]

\[ \Delta x = v_{ix} t + \frac{1}{2} a_x t^2 \]
\[ \Delta x = v_{ix} t + \frac{v_{ix} \Delta x}{v_{ix}} + \frac{\Delta x}{v_{iy} \sin \theta} \]
\[ t = 3.49 \text{ s} \]

Answers will be posted on the Structured Study Session web page: http://library.usask.ca/sss
b) \[ u_x = u_i x + a x t^2 \]
\[ u_x = u_i \cos \theta \]
\[ u_x = (25.0 \text{ m/s}) \cos 55.0^\circ \]
\[ u_x = 14.3 \text{ m/s} \]

\[ u_y = u_i y + a_y t \]
\[ u_y = u_i \sin \theta + (-g) t \]
\[ u_y = (25.0 \text{ m/s}) \sin 55.0^\circ + (-9.80 \text{ m/s}^2) (3.44 \text{ s}) \]
\[ u_y = -13.7 \text{ m/s} \]

\[ \sqrt{u_x^2 + u_y^2} \]
\[ \sqrt{(14.3 \text{ m/s})^2 + (-13.7 \text{ m/s})^2} \]
\[ u = 19.8 \text{ m/s} \]

\( u_y \)

\( u_x \)

c) \[ \Delta y = \frac{u_i y t + \frac{1}{2} a_y t^2}{\frac{1}{2} (-g) t^2} \]
\[ \Delta y = (u_i \sin \theta)t + \frac{1}{2} (-g) t^2 \]
\[ \Delta y = (25.0 \text{ m/s}) \sin 55.0^\circ)(3.44 \text{ s}) + \frac{1}{2} (-9.80 \text{ m/s}^2)(3.44 \text{ s})^2 \]
\[ \Delta y = 11.8 \text{ m} \]
B2.

(a) Free-body diagram:

\[ \begin{align*}
\sum F_x &= 0 \\
\sum F_y &= 0 \\
N &= m \cdot g + F_s \sin \theta
\end{align*} \]

(b) Constant velocity \( \Rightarrow \sum F_x = 0 \)

Also, \( \sum F_y = 0 \)

\[ \begin{align*}
F_x &= f_k \\
F_x &= \mu_k \cdot N \\
F_x &= \mu_k \cdot (m \cdot g + F_s \sin \theta) \\
\cos \theta &= \mu_k \cdot m \cdot g + \mu_k F_s \sin \theta \\
F(\cos \theta - \mu_k \cdot \sin \theta) &= \mu_k \cdot m \cdot g \\
F &= \frac{\mu_k \cdot m \cdot g}{\cos \theta - \mu_k \cdot \sin \theta}
\end{align*} \]
B3.

(a) 

\[ W_{nc} = \Delta E = E_f - E_i \]
\[ W_{nc} = (KE_f + PE_f) - (KE_i + PE_i) \]
\[ W_{nc} = KE_f - KE_i \]

Friction completely stops the bullet. \( KE_f = 0 \)
\[ W_{nc} = -KE_i \]
\[ W_{nc} = -\frac{1}{2} m v^2 = -\frac{1}{2} \left( 780 \times 10^{-3} \text{ kg} \right) (575 \text{ m/s})^2 \]
\[ W_{nc} = -1.29 \times 10^5 \text{ J} \]

Friction force is opposite to displacement, so it makes sense that \( W_{nc} < 0 \)

(b) 

Constant force, \( F = 1.91 \times 10^{-5} \text{ N} \)

Find \( \Delta x \)

\[ \Delta x = \frac{1}{2} (v_0 + v_f) t = \frac{1}{2} (575 \text{ m/s} + 0 \text{ m/s}) (1.91 \times 10^{-5} \text{ s}) \]
\[ \Delta x = 5.49 \times 10^{-2} \text{ m} = 5.49 \text{ cm} \]

(c) 

\[ W_{nc} = \left| F_{nc} \right| \Delta x \]

\[ W_{nc} = \left| F \right| \cos 180 \times \Delta x \]

\[ |F| = \frac{W_{nc}}{|\Delta x| \cos 180} = \frac{-1.29 \times 10^5 \text{ J}}{-5.49 \times 10^{-2} \text{ m}} = 2.35 \times 10^6 \text{ N} \]
B4. (a)

\( b = 5441 \text{ N/m} \)
\( x = 0.120 \text{ m} \)
\( m = 0.0200 \text{ kg} \)

\[ E_i = E_f \]

\[ KE_i + PE_{y_i} + PE_{st} = KE_f + PE_{y_f} + PE_{st} \]

Let the equilibrium position of the spring \( y = 0 \)

1. \( y = 0 \)
2. \( y_i = -0.120 \text{ m} \)

Then

\[ KE_i = 0 \]
\[ KE_f = 0 \text{ - max height} \]
\[ PE_{st} = 0 \text{ - not touching spring} \]

\[ PE_{y_i} + PE_{st} = PE_{y_f} \]

\[ mgy_i + \frac{1}{2} kx^2 = mgy_f \]

\[ y_f = \frac{kx^2}{2mg} = y_f \]

\[-0.120 \text{ m} + \frac{(5441 \text{ N/m})(-0.120 \text{ m})^2}{2(0.0200 \text{ kg})(9.8 \text{ m/s}^2)} = y_f \]

\[ y_f = 19.8 \text{ m} \]

See next page for part (b).
End of Part B

Good luck with your exams!

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 115, Bio 120, and Chem 112
- 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.

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