UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 115.3
MIDTERM TEST – Alternative Sitting

October 2013
Time: 90 minutes

NAME: ____________________________  STUDENT NO.: ____________
(Last)  (Given)

LECTURE SECTION (please check):
☐ 01 Dr. M. Ghezelbash
☐ 02 Dr. R. Pywell
☐ 03 B. Zulkoskey
☐ C15 F. Dean
☐ 97 Dr. R. Kleiv

INSTRUCTIONS:
1. This is a closed book exam.
2. The test package includes a test paper (this document), a formula sheet, and an OMR sheet. The test paper consists of 8 pages, including this cover page. It is the responsibility of the student to check that the test paper is complete.
3. Only a basic scientific calculator (e.g. Texas Instruments TI-30X series, Hewlett-Packard HP 10s or 30S) may be used. Graphing or programmable calculators, or calculators with communication capability, are not allowed.
4. Enter your name and student number on the cover of the test paper and check the appropriate box for your lecture section. Also enter your student number in the top right-hand corner of each page of the test paper.
5. Enter your name and STUDENT NUMBER on the OMR sheet.
6. The test paper, the formula sheet and the OMR sheet must all be submitted.
7. The marked test paper will be returned. The formula sheet and the OMR sheet will NOT be returned.

ONLY THE THREE PART B QUESTIONS THAT YOU INDICATE WILL BE MARKED
PLEASE INDICATE WHICH THREE PART B QUESTIONS ARE TO BE MARKED

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<tr>
<th>QUESTION NUMBER</th>
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<th>MAXIMUM MARKS</th>
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PART A

FOR EACH OF THE FOLLOWING QUESTIONS IN PART A, ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

A1. Given \( R = L, \ [v_0] = L/T, \ [g] = L/T^2 \), which one of the following equations is dimensionally correct?

- (A) \( R = \frac{v_0^2 \sin(2\theta)}{g} \)
- (B) \( R = \frac{v_0}{g} \)
- (C) \( R = \frac{v_0 g \sin(2\theta)}{T} \)
- (D) \( R = \frac{v_0}{g} \sin(2\theta) \)
- (E) \( R = \frac{g}{v_0} \sin(2\theta) \)

A2. A spherical balloon has a radius of \( r \) when it is fully inflated. The balloon is then deflated until its radius is \( r/2 \). Assuming that the balloon remains spherical as it is deflated, what is the ratio of the deflated and fully inflated surface areas?

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

A3. Use the rules for significant figures to correctly express the answer to this addition problem: 21.4 + 15 + 17.17 + 4.003.

- (A) 57.573
- (B) 57.57
- (C) 57.6
- (D) 58
- (E) 60

A4. The price of gasoline at a particular station is 1.5 euros per litre. An American student has 33 euros to buy gasoline. Knowing that there are 3.786 litres in a gallon, she quickly reasons that she can buy…

- (A) less than 1 gallon of gasoline.
- (B) about 6 gallons of gasoline.
- (C) about 8 gallons of gasoline.
- (D) about 10 gallons of gasoline.
- (E) more than 10 gallons of gasoline.

A5. When the pilot reverses the propeller in a boat moving north, the boat has an acceleration directed south. Assume the acceleration of the boat remains constant in magnitude and direction. What is the resulting motion of the boat?

- (A) It eventually stops and remains stopped.
- (B) It eventually stops and then moves faster and faster in the northward direction.
- (C) It eventually stops and then moves faster and faster in the southward direction.
- (D) It never stops but loses speed more and more slowly forever.
- (E) It never stops but continues to move faster and faster in the northward direction.

A6. A car moving at constant speed around a circular track…

- (A) has zero acceleration.
- (B) has an acceleration component in the direction of its velocity.
- (C) has an acceleration directed away from the centre of its circular path.
- (D) has an acceleration directed toward the centre of its circular path.
- (E) has an acceleration with a direction that cannot be determined from the information given.

A7. A model rocket is launched from the ground. It follows a curved path until it is eventually travelling horizontally at a height \( h \) above the horizontal ground at a speed \( v \). At that moment the rocket engine stops and the rocket falls to the ground. At the time the rocket engine stops the rocket has a mass \( m \). If we ignore the effects of the air, on which quantities does the time interval between when the rocket engine stops and the rocket hits the ground depend?

- (A) It depends on \( m \) and \( h \) but not \( v \).
- (B) It depends on \( h \) only.
- (C) It depends on \( v \) and \( h \) but not \( m \).
- (D) It depends on \( v \) and \( m \) but not \( h \).
- (E) It depends on all three quantities \( m, v \) and \( h \).
A8. A crate of mass $m$ is sliding down a ramp that is inclined at an angle of $\theta$ with the horizontal. The coefficient of kinetic friction between the crate and the ramp is $\mu_k$. The magnitude of the acceleration of the crate is...

\[ \sum F_y = 0 \Rightarrow n - mg \cos \theta = 0 \]
\[ \sum F_x = ma \Rightarrow w_x - f_x = ma \]
\[ mg \sin \theta - \mu_k mg \cos \theta = ma. \]

\[ (A) \ g \sin \theta, \quad (B) \ g \cos \theta, \quad (C) \ g (\cos \theta - \mu_k \sin \theta), \quad (D) \ g (\sin \theta - \mu_k \cos \theta), \quad (E) \ g \tan \theta. \]

A9. An object moves along the $x$-axis. The graph at right shows the velocity of the object as a function of time. Which one of the following graphs is a possible graph showing the position of the object as a function of time?

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A13. A mass $m$ is pushed against an ideal spring until the spring is compressed a distance $x$ from its equilibrium position. The force exerted by the spring is $F_1$ and the potential energy stored in the mass-spring system is $PE_1$. If the mass is now pushed until the compression of the spring is $2x$, how are the new force, $F_2$, and the new potential energy, $PE_2$, related to $F_1$ and $PE_1$?

\[ F_2 = 4F_1, \; PE_2 = 4PE_1 \]

\[ |F_{spring_2}| = kx \]

A14. Which one of the following statements concerning the physical quantity “work” is FALSE?

(A) Work is a scalar quantity.

(B) The work done on an object by a force depends on the angle between the force and the displacement.

(C) If the total work done on an object is zero, the object must be at rest.

(D) Positive work is done by a force when the force and the displacement are in the same direction.

(E) The component of force perpendicular to the displacement does not contribute to the work done by the force.

A15. An object of mass $m$ moving with speed $v$ in the $+x$ direction strikes an object of mass $2m$ which had been at rest. Following the collision, the object of mass $2m$ moves with speed $\frac{1}{2}v$ in the $+x$ direction. The velocity of the object of mass $m$ after the collision is

(A) zero.

(B) also $\frac{1}{2}v$ in the $+x$ direction.

(C) still $v$ in the $+x$ direction.

(D) $v$ in the $-x$ direction.

(E) impossible to determine without knowing whether or not the collision was elastic. \[ v_f = 0. \]

**PART B**

**ANSWER THREE OF THE** PART B QUESTIONS ON THE FOLLOWING PAGES AND **INDICATE YOUR CHOICE OF QUESTIONS ON THE COVER PAGE.**

**FOR EACH OF YOUR CHOSEN PART B QUESTIONS ON THE FOLLOWING PAGES, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED.**

**THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.**

**SHOW AND EXPLAIN YOUR WORK – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.**

**EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED.**

**USE THE BACK OF THE PREVIOUS PAGE FOR YOUR ROUGH WORK.**

continued on page 5...
B1. A stunt person is shot out of a cannon at an angle of 55.0° to the horizontal with an initial speed of 25.0 m/s. A net is positioned a horizontal distance of 50.0 m from the cannon. The end of the cannon may not be at the same height as the net. You may ignore any effects due to air resistance.

(a) Calculate the time after firing that the person reaches the horizontal position of the net.

\[
\Delta x = u_{0x} t \quad \Rightarrow \quad t = \frac{\Delta x}{u_{0x}} = \frac{50.0 \text{ m}}{25.0 \text{ m/s} \cos 55.0°} = 3.49 \text{ s}
\]

(b) Calculate the speed of the person when she reaches the horizontal position of the net. If you did not obtain an answer for (a), use a value of 3.75 s.

\[
u_x = u_{0x} \cos \theta = (25.0 \text{ m/s}) \cos 55.0° = 14.3 \text{ m/s}
\]

\[
u_y = u_{0y} + a_y t = u_{0y} \sin \theta - gt = (25.0 \text{ m/s}) \sin 55.0° - (9.80 \text{ m/s}^2)(3.49 \text{ s})
\]

\[
u_y = -13.7 \text{ m/s}
\]

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

Alt. Ans.: \(u_y = -16.3 \text{ m/s} ; U = 21.7 \text{ m/s}\)

(c) Calculate the height above the cannon that the net should be placed in order to catch the person.

\[
\Delta y = u_{0y} t + \frac{1}{2} a_y t^2
\]

\[
\Delta y = u_{0y} \sin \theta \cos \theta - \frac{1}{2} gt^2 = (25.0 \text{ m/s}) \sin 55.0° - \frac{1}{2} (9.80 \text{ m/s}^2)(3.49 \text{ s})^2 = 11.8 \text{ m}
\]

Alt. Method

\[
u_y^2 = u_{0y}^2 + 2a_y \Delta y
\]

\[
\Delta y = \frac{u_y^2 - u_{0y}^2}{2a_y} = \frac{(-13.7 \text{ m/s})^2 - (25.0 \text{ m/s})^2 \sin^2 (55.0°)}{-9.80 \text{ m/s}^2} = 11.8 \text{ m}
\]

continued on page 6...
B2. A coin of mass $m$ sits on top of a physics textbook. The textbook is gradually tilted, until it reaches an angle $\theta$ with the horizontal, at which point the coin begins to slide.

(a) Draw a free body diagram for the coin just before it starts to slide. (4 marks)

(b) Determine the expression for the coefficient of static friction $\mu_s$ between the textbook and the coin. Your answer may contain, at most, the symbols $m$, $\theta$, and $g$ and must be in its simplest form. (6 marks)

When the coin is on the verge of sliding, it is still in equilibrium:

$\sum F_i = 0 \Rightarrow \sum F_x = 0$ and $\sum F_y = 0$

$\sum F_x = 0 \Rightarrow F_{\text{max}} - F_{\text{grav}} \sin \theta = 0$

$\mu_s n - mg \sin \theta = 0 \quad (1)$

$\sum F_y = 0 \Rightarrow n - F_{\text{grav}} \cos \theta = 0 \Rightarrow n = mg \cos \theta \quad (2)$

(2) into (1):

$\mu_s (mg \cos \theta) - mg \sin \theta = 0$

$\mu_s (mg \cos \theta) = mg \sin \theta$

$\mu_s = \frac{\sin \theta}{\cos \theta}$

$\mu_s = \tan \theta$

continued on page 7...
B3. A child starts from rest and slides without friction from a height \( h = 5.00 \text{ m} \) along a curved waterslide. She is launched, at an angle \( \theta = 30.0^\circ \), from a height \( h/5 \), into the pool. You may ignore any resistive forces.

(a) Calculate her speed at the point where she leaves the waterslide. \((4 \text{ marks})\)

Choose the base of the slide (the water level) as the reference height for gravitational potential energy.

No resistive forces means mechanical energy is conserved.

\[
E_A = E_b \Rightarrow KE_A + PE_{grav_A} = KE_b + PE_{grav_b}
\]

\[
0 + mg h = \frac{1}{2} m v_A^2 + mg(h/5)
\]

\[
g(h - h/5) = \frac{v_A^2}{2}
\]

\[
v_A = \sqrt{2gh(4/5)} = \sqrt{2(9.80 \text{ m/s}^2)(5.00 \text{ m})(4/5)}
\]

\[v_A = 8.85 \text{ m/s}\]

(b) Calculate her maximum airborne height \( y_{\text{max}} \). If you did not obtain an answer for (a), use a value of \( 9.00 \text{ m/s} \). \((6 \text{ marks})\)

She is moving only horizontally at maximum height.

\[
u_c = u_{Bx} = u_B \cos \theta = (8.85 \text{ m/s}) \cos 30.0^\circ = 7.664 \text{ m/s}
\]

\[
E_A = E_c \Rightarrow \frac{1}{2} m v_c^2 + mg y_{\text{max}} = 0
\]

\[
y_{\text{max}} = h - \frac{v_c^2}{2g} = 5.00 \text{ m} - \left(\frac{7.664 \text{ m/s}}{2(9.80 \text{ m/s}^2)}\right)^2 = 2.00 \text{ m}
\]

Alternate method:

\[
u_{cy} = 0, \quad 2-d \text{ kinematics from } B \text{ to } C \text{ yields:}
\]

\[
u_{cy}^2 = u_{by}^2 + 2a_y \Delta y \Rightarrow \Delta y = \frac{u_{cy}^2 - u_{by}^2}{2a_y}
\]

\[
\Delta y = 0 - \frac{(8.85 \text{ m/s})^2 \sin^2(30.0^\circ)}{2(-9.80 \text{ m/s}^2)} = 1.00 \text{ m}
\]

\[
y_{\text{max}} = \frac{h}{5} + \Delta y = \frac{5.00 \text{ m}}{5} + 1.00 \text{ m} = 2.00 \text{ m}
\]

continued on page 8...
B4. Two objects of masses \(m\) and \(3m\) are moving toward each other along the \(x\)-axis with the same initial speed \(v_0\). The object of mass \(m\) is travelling to the left (\(-x\) direction) and the object of mass \(3m\) is travelling to the right (\(+x\) direction). They undergo a glancing collision such that the object of mass \(m\) is moving in the \(-y\) direction after the collision, at a right angle from its initial direction. After the collision, the object of mass \(3m\) is moving at 2.00 m/s at an angle of 30.0° counterclockwise from the \(+x\) axis.

(a) Calculate the after-collision speed of the object of mass \(m\). (5 marks)

Using \(y\)-equation:

\[
3m(\vec{u_{3f}} \sin \theta_3) - m \vec{u_{1f}} = 0
\]

\[
\vec{u_{1f}} = 3 \vec{u_{3f}} \sin \theta_3
\]

\[
\vec{u_{1f}} = 3 \left(2.00 \text{ m/s}\right) \sin 30.0°
\]

\[
\vec{u_{1f}} = 3.00 \text{ m/s}
\]

(b) Calculate the before-collision speed of the masses. (5 marks)

Apply cons. of momentum in the \(x\) direction:

\[
P_{xf} + \vec{u_{1f}} = P_{xf} + \vec{u_{1f}}
\]

\[
3m \vec{u_{3f}} \cos \theta_3 = 3m \vec{v_0} - m \vec{v_0}
\]

\[
3 \vec{u_{3f}} \cos \theta_3 = 2 \vec{v_0}
\]

\[
\vec{v_0} = \frac{3 \vec{u_{3f}} \cos \theta_3}{2} = \frac{3 \left(2.00 \text{ m/s}\right) \cos (30.0°)}{2}
\]

\[
\vec{v_0} = 2.60 \text{ m/s}
\]

\[
\vec{v_0} = 2.60 \text{ m/s}
\]