UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 115.3
MIDTERM TEST – Alternative Sitting

October 2010 Time: 90 minutes

NAME: MASTER STUDENT NO.: ___________
(Last) **Please Print** (Given)

LECTURE SECTION (please check):

- ❑ 01 B. Zulkoskey
- ❑ 02 Dr. R. Pywell
- ❑ 03 Dr. K. McWilliams
- ❑ C15 F. Dean

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. **It is the responsibility of the student to check that the test paper is complete.**
3. Only Hewlett-Packard HP 10s or HP 30s or Texas Instruments TI-30X series calculators may be used.
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

QUESTION NUMBER	TO BE MARKED	MAXIMUM MARKS	MARKS OBTAINED
A1-15	-	15	
B1	❑	10	
B2	❑	10	
B3	❑	10	
B4	❑	10	
TOTAL		45	

continued on page 2...

PART A

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

$v = \sqrt{\frac{\gamma k_B T}{m}}$

$v^2 = \frac{\gamma k_B T}{m}$

$k_B = \frac{m v^2}{\gamma T}$

$[k_B] = \frac{kg \cdot m^2/s^2}{K}$

$[k_B] = kg \cdot m^2 \cdot s^{-2} \cdot K^{-1}$

(C)

C

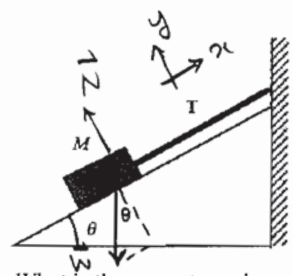
A1. The equation for the speed of sound v in a gas is $v = \sqrt{\frac{\gamma k_B T}{m}}$. Speed v is measured in m/s, γ is a dimensionless constant, T is temperature in kelvins (K), and m is mass in kg. What are the units for the Boltzmann constant k_B?

(A) kg m^2 s^2 K (B) kg^{-1} m^{-2} s^2 K (C) kg m^2 s^{-2} K^{-1} (D) kg m s^{-1} (E) kg m s^{-2}

E

A2. A block of mass M is held motionless on a frictionless inclined plane by means of a string attached to a vertical wall as shown in the drawing. What is the magnitude of the tension T in the string?

(A) zero (B) Mg (C) $Mg \cos\theta$
(D) $Mg \tan\theta$ (E) $Mg \sin\theta$



$\Sigma F_x = 0$ (motionless)

$T - W\sin\theta = 0$

$T = W\sin\theta$

$T = mg\sin\theta$

D

A3. We add the three lengths: 3.22×10^{-3} m + 12.0061 m + 6.80752 m. What is the correct number of significant figures in the result?

(A) 3 (B) 4 (C) 5 (D) 6 (E) 7

12.0061 m
6.80752 m
0.00322 m
6 sig. fig

B

A4. The average size of a transistor in a microchip is about 200 nanometres across. The diameter of a human hair is about 70 micrometres. What is the order of magnitude of the number of microchip transistors that can fit across the width of a human hair?

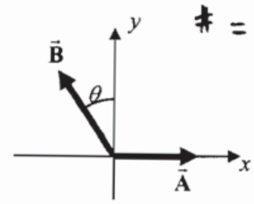
(A) 10^1 (B) 10^2 (C) 10^3 (D) 10^4 (E) 10^5

$\# = \frac{70 \times 10^{-6} m}{200 \times 10^{-9} m}$

$\# = 350 \simeq 100$

D

A5. The figure shows two vectors $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$. The angle θ is the magnitude of the angle between the $+y$-axis direction and the direction of the vector $\vec{\mathbf{B}}$ as shown. The components of the vector $\vec{\mathbf{R}} = \vec{\mathbf{A}} + \vec{\mathbf{B}}$ are



(A) $R_x = A + B\cos\theta, \quad R_y = B\sin\theta$
(B) $R_x = A - B\cos\theta, \quad R_y = B\sin\theta$
(C) $R_x = A + B\sin\theta, \quad R_y = B\cos\theta$
(D) $R_x = A - B\sin\theta, \quad R_y = B\cos\theta$
(E) $R_x = A - B, \quad R_y = B\tan\theta$

B

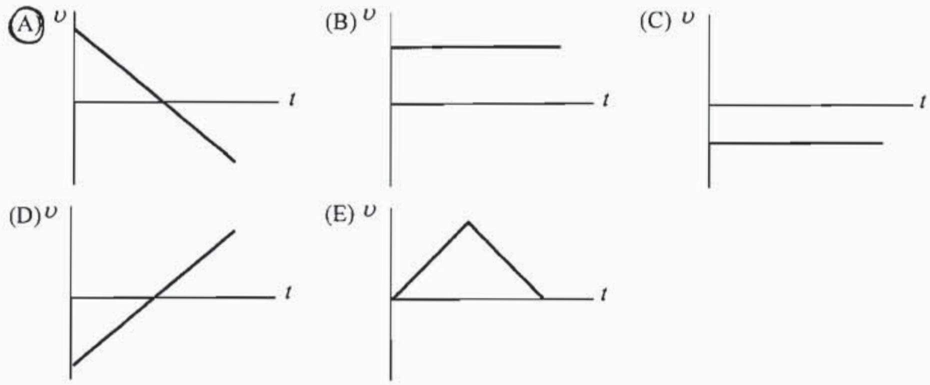
A6. A ball is thrown straight up into the air. Ignoring air resistance, while in the air the ball's acceleration

(A) is zero.
(B) remains constant.
(C) decreases on the way up and increases on the way back down.
(D) increases.
(E) changes direction.

continued on page 3...

A7. A ball is thrown vertically upward. Eventually it returns to the point from which it was thrown. Which one of the following velocity versus time graphs is correct for the motion of the ball while it is in free fall? (Up has been chosen as the positive direction and air resistance is negligible.)

A



A8. The term *force* most accurately describes

E

(A) the mass of an object.
(B) the inertia of an object.
(C) the quantity that causes displacement.
(D) the quantity that keeps an object moving.
(E) the quantity that changes the velocity of an object.

$\Sigma\vec{F} = m\vec{a}$

rate of change of velocity

A9. Which car has a westward acceleration?

C

(A) a car travelling westward at a constant speed — $a = 0$
(B) a car travelling westward and slowing down — $\vec{a}$ East
(C) a car travelling eastward and slowing down — $\vec{a}$ West
(D) a car travelling eastward and speeding up — $\vec{a}$ East
(E) a car starting from rest and moving toward the east — $\vec{a}$ East

A10. Two children ride on a merry-go-round. George is at a greater distance from the axis of rotation than Jacques. Comparing their linear speeds and their angular speeds with respect to the merry-go-round axis of rotation, which statement is correct?

C

(A) George has the same linear speed as Jacques, but a greater angular speed than Jacques.
(B) George has a greater linear speed than Jacques, and a greater angular speed than Jacques.
(C) George has a greater linear speed than Jacques, but the same angular speed as Jacques.
(D) George has the same linear speed as Jacques, and the same angular speed as Jacques.
(E) George has a smaller linear speed than Jacques, but the same angular speed as Jacques.

$\omega_J = \omega_G$

$\frac{v_J}{R_J} = \frac{v_G}{R_G}$

$v_G = \frac{R_G}{R_J} \cdot v_J$

$v_G > v_J$

since $R_G > R_J$

A11. A space probe leaves the solar system to explore interstellar space. Once it is far from any other objects, when must it fire its rocket engines?

E

(A) all the time, in order to keep moving
(B) only when it wants to speed up
(C) only when it wants to speed up or slow down
(D) only when it wants to change direction
(E) when it wants to speed up, slow down, or change direction

continued on page 4...

$\Sigma F_r = ma_r$

Let P = Period

$v_1 = \frac{2\pi R}{P_1}$

A12. A ball on a string moves around a complete circle, once a second, on a frictionless, horizontal table. The tension in the string is T. What would the tension be if the ball went around in only half a second?

E

(A) ¼ T (B) ½ T (C) T (D) 2 T (E) 4 T

$P_2 = \frac{1}{2}P_1 \Rightarrow v_2 = 2v_1$; $\Sigma F_r = T_1 = mv_1^2/R_1$; $T_2 = mv_2^2/R_1$; $T_2 = 4T_1$

A13. Two satellites are in orbit about the Earth with the same orbital radius. Satellite B has twice the mass of satellite A. The radial acceleration of satellite B has a magnitude that is

A

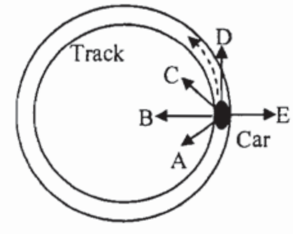
(A) the same as the magnitude of the radial acceleration of satellite A.
(B) one half the magnitude of the radial acceleration of satellite A.
(C) two times the magnitude of the radial acceleration of satellite A.
(D) four times the magnitude of the radial acceleration of satellite A.
(E) eight times the magnitude of the radial acceleration of satellite A.

$v_A = v_B$ since $R_A = R_B$

$a_r = \frac{v^2}{R}$ = constant

so a_r = same (constant)

A14. A car is driving at a constant speed around a circular track. In the diagram the car is moving counter clockwise. Which of the arrows best represents the direction of the net force on the car when it is at the position shown?



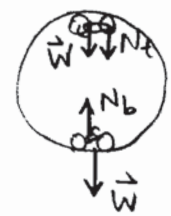
B

(A) A
(B) B
(C) C
(D) D
(E) E

A15. A motorcycle stunt rider drives his motorcycle at a constant speed in a vertical loop-the-loop. The magnitude of the normal force of the loop on the motorcycle is

B

(A) greatest at the top of the loop.
(B) greatest at the bottom of the loop.
(C) greatest when the motorcycle is moving vertically upward.
(D) greatest when the motorcycle is moving vertically downward.
(E) the same everywhere on the loop.



At top $\Sigma F_r = ma_r$

$W + N_t = ma_r$

$N_t = ma_r - W$

At bottom.

$\Sigma F_r = ma_r$

$N_b - W = ma_r \Rightarrow N_b = ma_r + W$

PART B

ANSWER THREE OF THE PART B QUESTIONS ON THE FOLLOWING PAGES AND INDICATE YOUR CHOICES 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.

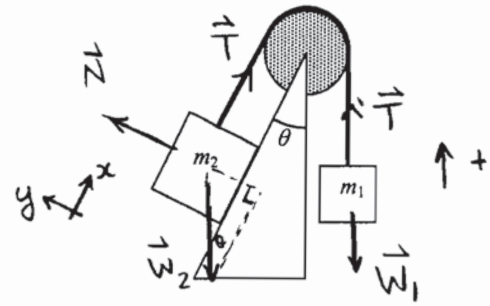
SHOW AND EXPLAIN YOUR WORK – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.

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. The figure shows a system which is in equilibrium. The mass of the string is negligible and the pulley has negligible mass and negligible friction. The inclined plane has an angle $\theta = 30.0°$ with the vertical. The hanging object has mass $m_1 = 5.00$ kg. The inclined plane is coated with a layer of ice so that friction between the mass m_2 and the inclined plane is negligible.



(a) Calculate the tension in the string. (*3 marks*)

Newton I for m_1:

$\boxed{49.0\text{ N}}$

$$\Sigma \vec{F} = 0 \Rightarrow T - W_1 = 0$$

$$T = m_1 g = (5.00\text{ kg})(9.80\text{ m/s}^2)$$

$$T = 49.0\text{ N}$$

(b) Calculate m_2. If you did not obtain an answer for (a) use a value of 52.5 N. (*4 marks*)

Newton I for $m_2 \Rightarrow \Sigma \vec{F} = 0$

$\boxed{5.77\text{ kg}}$

In x-dir'n, $\Sigma F_x = 0$

$$T_x + W_{2x} = 0 \Rightarrow T - W_2 \cos\theta = 0 \Rightarrow T - m_2 g \cos\theta = 0$$

$$T = m_2 g \cos\theta \Rightarrow m_2 = \frac{T}{g\cos\theta} = \frac{49.0\text{N}}{(9.80\text{m/s}^2)(\cos 30.0°)} = 5.77\text{kg}$$

(c) Calculate the magnitude of the normal force of the plane on m_2. If you did not obtain an answer for (b) use a value of 6.25 kg. (*3 marks*)

In y-dir'n, $\Sigma F_y = 0$

$\boxed{28.3\text{ N}}$

$$N_y + W_{2y} = 0$$

$$N - W_2 \sin\theta = 0$$

$$N = W_2 \sin\theta = m_2 g \sin\theta$$

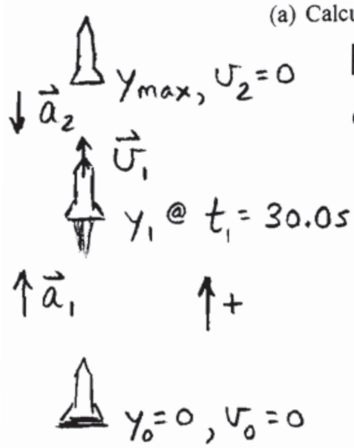
$$N = (5.77\text{ kg})(9.80\text{ m/s}^2)(\sin 30.0°) = 28.3\text{ N}$$

continued on page 6...

Stu. No.: ____________________

B2. A rocket is launched straight up from rest. It accelerates upward with a constant acceleration of 30.0 m/s^2 for 30.0 seconds. At t = 30.0 s the rocket is out of fuel and the rocket engine is no longer exerting a force on the rocket. You may ignore any effects due to air resistance and you may assume that the value of g does not change appreciably during the flight of the rocket.

(a) Calculate the altitude of the rocket at time t = 30.0 s. (*3 marks*)



For the first 30.0s, the acceleration is constant at $a_1 = +30.0 m/s^2$

$\boxed{1.35 \times 10^4 m}$

$$y_1 = v_0 t_1 + \frac{1}{2} a_1 t_1^2$$

$$y_1 = 0 + \frac{1}{2}(+30.0 m/s^2)(30.0s)^2$$

$$y_1 = 1.35 \times 10^4 m$$

(b) Calculate the maximum altitude that the rocket reaches. (*5 marks*)

Let $\Delta y = y_{max} - y_1$ = distance travelled after engine shuts off

$\boxed{5.48 \times 10^4 m}$

Accel'n is now constant at $a_2 = -g = -9.80 m/s^2$

$v_2^2 - v_1^2 = 2a_2 \Delta y$ where v_1 = velocity at $t = 30.0s$

$$v_1 = v_0 + a_1 t_1 = 0 + a_1 t_1 = a_1 t_1$$

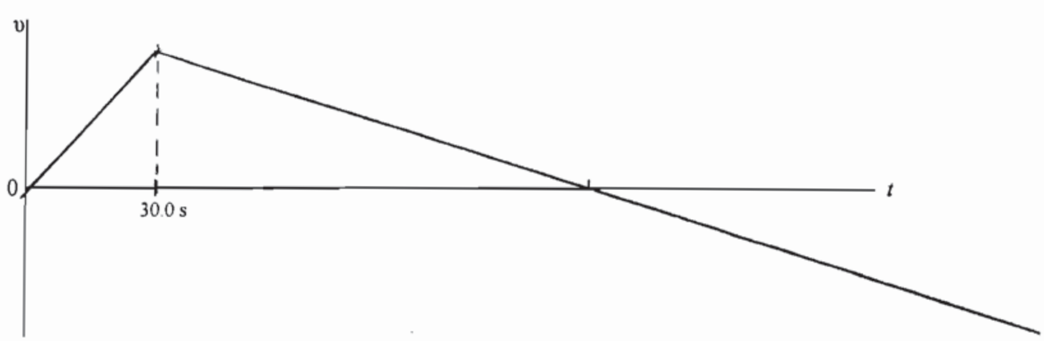
so $v_2^2 - a_1^2 t_1^2 = 2a_2 \Delta y \Rightarrow \Delta y = \dfrac{0 - a_1^2 t_1^2}{2a_2} = -\dfrac{a_1^2 t_1^2}{2a_2}$

$$\Delta y = -\frac{(+30.0 m/s^2)^2 (30.0s)^2}{2(-9.80 m/s^2)} = 4.13 \times 10^4 m$$

; $y_{max} = y_1 + \Delta y$

$y_{max} = 5.48 \times 10^4 m$

(c) Sketch the velocity versus time graph for the rocket from the time it was launched until it hits the ground. Numerical labels are not required. (*2 marks*)



continued on page 7...

B3. A satellite moves in a stable circular orbit around the Earth at a speed of 5.52×10^3 m/s.

(a) Calculate the height of the satellite above the Earth's surface. (*4 marks*)

Newton II for circular motion.

$$\Sigma F_r = ma_r$$

$$F_{grav} = \frac{mv^2}{r}$$

$$\frac{GM_E \cancel{m}}{r^{\cancel{2}}} = \frac{\cancel{m}v^2}{\cancel{r}}$$

$$r = \frac{GM_E}{v^2} = 1.31 \times 10^7 \text{ m}$$

$$h = r - R_E$$

$$\boxed{6.72 \times 10^6 \text{ m}}$$

$$h = \frac{(6.674 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2)(5.98 \times 10^{24} \text{ kg})}{(5.52 \times 10^3 \text{ m/s})^2} - 6.38 \times 10^6 \text{ m} = 6.72 \times 10^6 \text{ m}$$

(b) Calculate the magnitude of the acceleration due to gravity at the satellite's location. If you did not obtain an answer for (a) use a value of 7.25×10^6 m. (*3 marks*)

$$\boxed{2.33 \text{ m/s}^2}$$

$$a_r = \frac{v^2}{r} = \frac{(5.52 \times 10^3 \text{ m/s})^2}{1.31 \times 10^7 \text{ m}}$$

$$a_r = 2.33 \text{ m/s}^2$$

(c) Calculate the orbital period of the satellite. If you did not obtain an answer for (a) use a value of 7.25×10^6 m. (*3 marks*)

$$\boxed{1.49 \times 10^4 \text{ s}}$$

$$v = \frac{2\pi r}{T}$$

$$T = \frac{2\pi r}{v} = \frac{2\pi (1.31 \times 10^7 \text{ m})}{5.52 \times 10^3 \text{ m/s}} = 1.49 \times 10^4 \text{ s}$$

continued on page 8...

B4. A pendulum is made from a ball, of mass $m = 0.500$ kg, attached to a string of length $L = 55.0$ cm. As the ball swings through the lowest point in its motion, the tension in the string is exactly two times the weight of the ball.

(a) Draw a free body diagram for the ball when at the lowest point in its motion. (*2 marks*)

(b) Calculate the speed of the ball at the lowest point in its motion. (~~4~~ 5 *marks*)

Newton II for circular motion.

$\boxed{2.32\ \text{m/s}}$

$$\Sigma F_r = m a_r$$

$$T - W = \frac{mv^2}{r}$$

$$2mg - mg = \frac{mv^2}{r}$$

$$\cancel{m}g = \frac{\cancel{m}v^2}{r}$$

$$v = \sqrt{rg}$$

$$v = \sqrt{(0.550\,\text{m})(9.80\,\text{m/s}^2)}$$

$$v = 2.32\,\text{m/s}$$

(c) Calculate the magnitude of the radial acceleration of the ball at the lowest point in its motion. (~~4~~ 3 *marks*)

$\boxed{9.79\ \text{m/s}^2}$

$$a_r = \frac{v^2}{r}$$

$$a_r = \frac{(2.32\,\text{m/s})^2}{0.550\,\text{m}} = 9.79\,\text{m/s}^2$$

or

$$T - W = m a_r$$

$$2mg - mg = m a_r$$

$$mg = m a_r$$

$$g = a_r$$

$$a_r = 9.80\,\text{m/s}^2$$

END OF EXAMINATION