UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 115.3
MIDTERM TEST – Alternative Sitting

October 2011

Time: 90 minutes

NAME: MASTER
(Last) **Please Print** (Given)

STUDENT NO.: ____________

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, or a calculator approved by your instructor, 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...

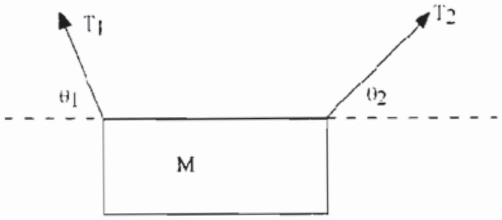
PART A

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

A1. A traffic light of mass M hangs from two cables. Cable 1 has a tension of magnitude T_1, and the cable makes an angle θ_1 with the horizontal, as shown. Cable 2 has a tension of magnitude T_2, and the cable makes an angle θ_2 with the horizontal, as shown. Which one of the following equations is valid for the traffic light?

B

(A) $T_1 + T_2 = Mg$
[✓ (B)] $T_1 \cos\theta_1 = T_2 \cos\theta_2$
(C) $T_1 \sin\theta_1 = T_2 \cos\theta_2$
(D) $T_1 \cos\theta_1 = T_2 \sin\theta_2$
(E) $T_1 \sin\theta_1 = T_2 \sin\theta_2$



A2. Using the dimensions given for the symbols in the table, determine which one of the following expressions is dimensionally correct.

C

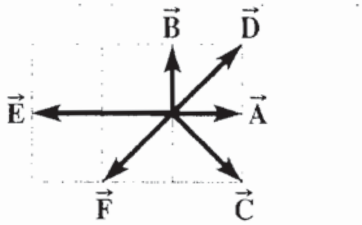
symbol	dimension
f	$\frac{1}{[\mathrm{T}]}$
l	$[\mathrm{L}]$
g	$\frac{[\mathrm{L}]}{[\mathrm{T}]^2}$

(A) $f = \frac{g}{2\pi l}$ (B) $f = 2\pi g l$ [✓ (C)] $2\pi f = \sqrt{\frac{g}{l}}$ (D) $2\pi f = \sqrt{\frac{l}{g}}$ (E) $f = 2\pi\sqrt{gl}$

A3. Vector $\vec{A}$ in the drawing is equal to

D

(A) $\vec{C} + \vec{D}$
(B) $\vec{C} + \vec{D} + \vec{E}$
(C) $\vec{C} + \vec{F}$
[✓ (D)] $\vec{B} + \vec{C}$
(E) $\vec{B} + \vec{F}$



A4. By what factor does the volume of a cube increase if the lengths of the edges are doubled?

B

(A) 16 [✓ (B)] 8 (C) 4 (D) 2 (E) $\sqrt{2}$

A5. You have just performed an experiment in which you measured many values of two quantities, A and B. According to theory, $A = cB^3 + A_o$. You want to make a graph of your data that enables you to determine the values of c and A_o from a slope and a vertical axis intercept. What quantities do you put on the vertical and horizontal axes of the plot?

A

[✓ (A)] A vertical, B^3 horizontal (B) A vertical, B horizontal
(C) B vertical, A horizontal (D) B vertical, A^3 horizontal
(E) A vertical, $\sqrt[3]{B}$ horizontal

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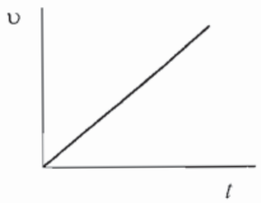
A6. An object is undergoing straight-line motion and the graph of its velocity versus time is shown in the diagram. Which one of the following statements is correct for the situation described by the graph?



C

(A) The velocity of the object is constant.
(B) The velocity of the object is given by the slope of the graph.
[✓ (C)] The acceleration of the object is constant.
(D) The acceleration of the object is increasing with time.
(E) The acceleration of the object is decreasing with time.

A7. A ball is kicked at an angle of 30° above the horizontal ground. Ignoring air resistance, which one of the following statements correctly describes the situation at the top of the ball's trajectory?

D

(A) The velocity and acceleration of the ball are in opposite directions.
(B) The velocity and acceleration of the ball are both zero.
(C) The velocity and acceleration of the ball are parallel.
[✓ (D)] The velocity and acceleration of the ball are perpendicular.
(E) The velocity and acceleration of the ball have their maximum magnitudes.

A8. If a net force, with magnitude F, acts on a blue object with mass m, the object has an acceleration with magnitude a. If a net force with a magnitude which is 6 times F acts on a red object with mass 3 times m, the red object has an acceleration with magnitude…

B

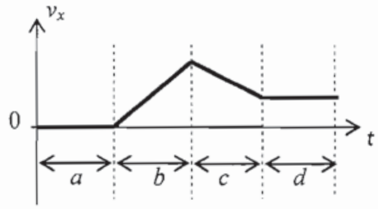
(A) $3a$ [✓ (B)] $2a$ (C) $a/2$ (D) $a/6$
(E) that cannot be determined, since the answer depends on the direction of the net force acting on the red object.

A9. A pebble (Pebble 1) is thrown horizontally from the top of a tall cliff and lands on the horizontal ground below. At the same time, a second pebble (Pebble 2) is dropped (released from rest) from the top of the cliff. Which one of the following statements is correct?

C

(A) Pebble 1 reaches the ground first, and it has a speed greater than Pebble 2 has when Pebble 2 reaches the ground.
(B) Pebble 2 reaches the ground first, and it has a speed greater than Pebble 1 has when ball Pebble 1 reaches the ground.
[✓ (C)] Both pebbles hit the ground at the same time, but Pebble 1 has a speed greater than Pebble 2 when they reach the ground.
(D) Pebble 1 reaches the ground first, but both pebbles have the same speed when they reach the ground.
(E) Pebble 2 reaches the ground first, but both pebbles have the same speed when they reach the ground.

A10. An object moves along the x-axis. The graph shows the velocity of the object as a function of time. In which time interval(s) (labeled a, b, c and d on the graph) is the acceleration of the object zero?



D

(A) Time intervals a, b, c and d.
(B) Time intervals b, c and d.
(C) Time intervals b and c.
[✓ (D)] Time intervals a and d.
(E) Time interval a only.

continued on page 4...

A11. Consider an object moving in a circular path with constant speed. Which one of the following statements is **TRUE**?

B

(A) The speed is constant so the magnitude of the acceleration is zero.
[✓ (B)] The speed is constant so the component of the acceleration in the direction of motion is always zero.
(C) The distance from the center is constant so the radial component of the velocity is always zero so the radial component of the acceleration must be zero.
(D) The component of the acceleration in the direction of motion is not zero.
(E) The radial component of the acceleration and the component of acceleration in the direction of motion have equal magnitudes.

A12. A car travels around a circular curve without slipping. When the road surface is horizontal, which force is responsible for holding the car on the road in the circular path as it travels around the curve?

C

(A) the weight of the car
(B) the kinetic friction force between the tires of the car and the road
[✓ (C)] the static friction force between the tires of the car and the road
(D) the vertical component of the normal force
(E) the horizontal component of the normal force

A13. A big truck and a small car drive around the same circular curve in a road. The mass of the truck is four times larger than the mass of the car. If they drive around the curve at the same speed then what is the ratio of the radial acceleration of the truck, a_{rt}, compared to that of the car, a_{rc}. In other words, what is a_{rt}/a_{rc}?

C

(A) 4 (B) 2 [✓ (C)] 1 (D) ½ (E) ¼

A14. An object is moving with an angular speed ω_1 in a uniform circular path of radius r_1. If the angular speed is doubled and the radius remains the same then which one of the following expressions for the new radial acceleration is correct?

B

(A) $2r_1\omega_1^2$ [✓ (B)] $4r_1\omega_1^2$ (C) $8r_1\omega_1^2$ (D) $r_1\omega_1^2$ (E) $6r_1\omega_1^2$

A15. A satellite of mass m moves with a speed v in a stable circular orbit around the Earth. If a second satellite of mass $2m$ is placed in the same stable circular orbit, what must be its speed in order to maintain this orbit?

C

(A) ¼ v (B) ½ v [✓ (C)] v (D) 2 v (E) 4 v

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.

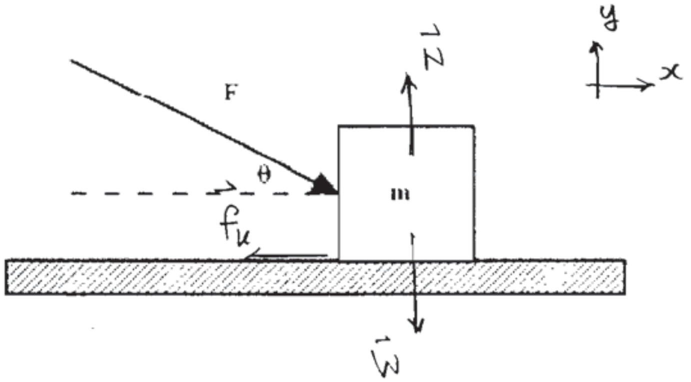
SHOW AND EXPLAIN YOUR WORK – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.

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. A block with mass m is being pushed by a force **F** that makes an angle of θ with the horizontal, as shown. The block is moving with constant velocity on a level surface. The coefficient of kinetic friction between the block and the surface is μ_k.



(a) Draw the free body diagram of the block. (*4 marks*)

(b) Derive an expression for the magnitude of the pushing force F in terms of the variables given. (*6 marks*)

Constant velocity $\Rightarrow \Sigma \vec{F} = 0$

$\Sigma F_x = 0$ and $\Sigma F_y = 0$

$$\boxed{F = \frac{\mu_k mg}{\cos\theta - \mu_k \sin\theta}}$$

$F_x + f_{k_x} = 0$

$+ F\cos\theta - f_k = 0$

$F = \dfrac{f_k}{\cos\theta}$

$F_y + N_y + W_y = 0$

$- F\sin\theta + N - W = 0$

$N = W + F\sin\theta$

$N = mg + F\sin\theta$

and $f_k = \mu_k N$

$$F = \frac{\mu_k N}{\cos\theta} = \frac{\mu_k(mg + F\sin\theta)}{\cos\theta}$$

$$F = \frac{\mu_k mg}{\cos\theta} + \mu_k F \tan\theta$$

$$F - F(\mu_k \tan\theta) = \frac{\mu_k mg}{\cos\theta}$$

$$F(1 - \mu_k \tan\theta) = \frac{\mu_k mg}{\cos\theta}$$

$$F = \frac{\mu_k mg}{\cos\theta(1 - \mu_k \tan\theta)} = \boxed{\frac{\mu_k mg}{\cos\theta - \mu_k \sin\theta}}$$

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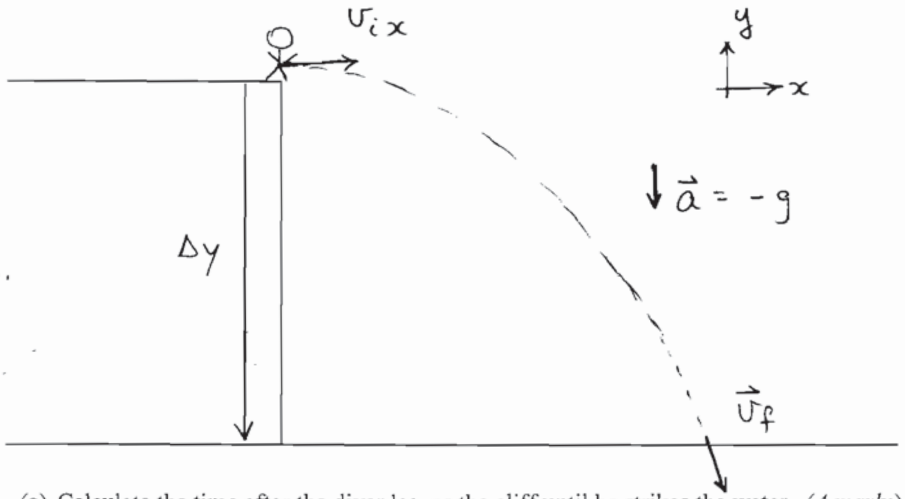
B2. A cliff diver has a speed of 1.35 m/s as he runs horizontally off a cliff overlooking a lake. The cliff is 5.60 m above the lake. You may ignore any effects due to air resistance.



(a) Calculate the time after the diver leaves the cliff until he strikes the water. (*4 marks*)

$\boxed{1.07\,s}$

x	y
$\Delta x = ?$	$\Delta y = -5.60m$
$v_{ix} = 1.35m/s$	$v_{iy} = 0$
$a_x = 0$	$a_y = -g$
$v_{fx} = 1.35m/s$	$v_{fy} = ?$
$\Delta t = ?$	

$$\Delta y = v_{iy}\Delta t + \frac{1}{2}a_y(\Delta t)^2$$

$$\Delta y = 0 - \frac{1}{2}g(\Delta t)^2$$

$$\Delta t = \sqrt{\frac{2\Delta y}{-g}}$$

$$\Delta t = \sqrt{\frac{2(-5.60m)}{-(9.80m/s^2)}} = \boxed{1.07s}$$

(b) Calculate the diver's speed just before striking the water. (If you did not obtain an answer for (a), use a value of 1.00 s.) (*6 marks*)

$\boxed{10.6\,m/s}$

$$v_{fx} = v_{ix} = 1.35\,m/s \quad (b/c\ a_x = 0)$$

$$v_{fy}^2 - v_{iy}^2 = 2a_y(\Delta y)$$

$$v_{fy}^2 - 0 = 2(-g)(\Delta y)$$

$$v_{fy} = -\sqrt{2(-9.80m/s^2)(-5.60m)} = -10.5\,m/s$$

$$v_f = \sqrt{v_{fx}^2 + v_{fy}^2} = \sqrt{(1.35m/s)^2 + (-10.5\,m/s)^2}$$

$$\boxed{v_f = 10.6\,m/s}$$

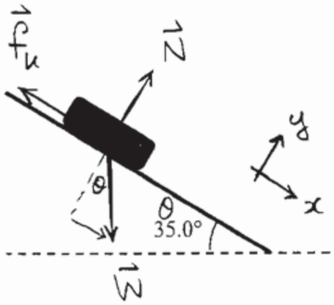
ALT ANS (using $\Delta t = 1.00s$)

$$v_{fy} = v_{iy} + a_y\Delta t = -9.80\,m/s$$

continued on page 7...

$$v_f = 9.89\,m/s$$

B3. A book is placed on a wooden plank which is at an angle of 35.0° to the horizontal. After the book is released it slides down the plank. The coefficient of kinetic friction between the book and the plank is 0.429.



(a) Draw a free body diagram for the book. (*3 marks*)

(b) Calculate the acceleration of the book after it is released. (*4 marks*)

Choose x-axis along plank as shown.

$$\boxed{2.18\,\text{m/s}^2}$$

$\Sigma F_x = ma$ and $\Sigma F_y = 0$

$W_x + f_{kx} = ma$ $N_y + W_y + f_{ky} = 0$

$+mg\sin\theta - f_k = ma$ $+N - mg\cos\theta + 0 = 0$

$N = mg\cos\theta$

$mg\sin\theta - \mu_k N = ma$

$mg\sin\theta - \mu_k(mg\cos\theta) = ma$

$a = g(\sin\theta - \mu_k\cos\theta)$

$a = 9.80\,\text{m/s}^2(\sin 35.0° - 0.429\cos 35.0°)$

$$\boxed{a = 2.18\,\text{m/s}^2}$$

(c) If the book was released from rest, calculate the speed of the book after it has moved down the plank a distance of 66.0 cm. (If you did not obtain an answer for (b), use a value of 2.25 m/s^2.) (*3 marks*)

$$\boxed{1.70\,\text{m/s}}$$

$v_{fx}^2 - v_{ix}^2 = 2a_x \Delta x$

$v_{fx}^2 - 0 = 2a_x \Delta x$

$v_{fx} = \sqrt{2a_x\Delta x} = \sqrt{2(2.18\,\text{m/s}^2)(0.660\,\text{m})}$

$$\boxed{v_{fx} = 1.70\,\text{m/s}}$$

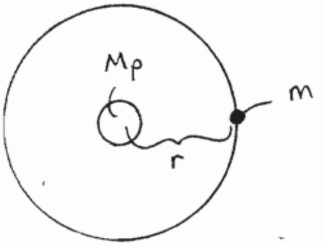
ALT ANS: 1.72 m/s

continued on page 8...

B4. A small moon orbits a large planet. The radius of the moon's orbit is 6.71×10^8 m and it takes the moon 3.07×10^5 s to complete one orbit.

(a) Calculate the angular speed of the moon in its orbit around the planet, in rad/s. (*4 marks*)

$$\boxed{2.05 \times 10^{-5}\ \text{rad/s}}$$



$$\omega_{av} = \frac{\Delta\theta}{\Delta t} = \frac{2\pi\ \text{rad}}{T}$$

$$\omega = \frac{2\pi\ \text{rad}}{3.07 \times 10^5\,\text{s}} = \boxed{2.05 \times 10^{-5}\ \text{rad/s}}$$

(b) Given that the moon is kept in a circular orbit by the gravitational force of the planet on the moon, calculate the mass of the planet. (*6 marks*)

$$\boxed{1.90 \times 10^{27}\ \text{kg}}$$

For circular motion, $\Sigma F_r = ma_r$

$$\Sigma F_r = ma_r$$

The gravitational force of the planet on the moon causes the radial acceleration of the moon.

$$F_{grav} = m(r\omega^2)$$

$$\frac{G M_p \cancel{m}}{r^2} = \cancel{m} r \omega^2$$

$$M_p = \frac{r^3\omega^2}{G} = \frac{(6.71 \times 10^8\,\text{m})^3 (2.05 \times 10^{-5}\ \text{rad/s})^2}{6.674 \times 10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2}$$

$$M_p = 1.90 \times 10^{27}\ \frac{\text{kg}^2 \cdot \text{m}^3/\text{s}^2}{\text{kg}\cdot\text{m}\cdot\text{m}^2/\text{s}^2}$$

$$\boxed{M_p = 1.90 \times 10^{27}\ \text{kg}}$$

END OF EXAMINATION