UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 115.3
MIDTERM TEST – Alternative Sitting

October 25, 2012 Time: 90 minutes

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

LECTURE SECTION (please check):

- ❑ 01 B. Zulkoskey
- ❑ 02 Dr. R. Pywell
- ❑ 03 Dr. M. Ghezelbash
- ❑ 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, including this cover page. **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. 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	L
g	$\frac{\mathrm{L}}{\mathrm{T}^2}$

$\frac{L/T^2}{L} = \frac{1}{T^2}$ X

$\sqrt{\frac{L/T^2}{L}} = \sqrt{\frac{1}{T^2}} = \frac{1}{T}$ ✓

$\sqrt{\frac{L}{T^2}\cdot L} = L/T$ X

(A) $f = \dfrac{g}{2\pi l}$ (B) $f = 2\pi g l$ (C) $2\pi f = \sqrt{\dfrac{g}{l}}$ (D) $2\pi f = \sqrt{\dfrac{l}{g}}$ (E) $f = 2\pi\sqrt{gl}$

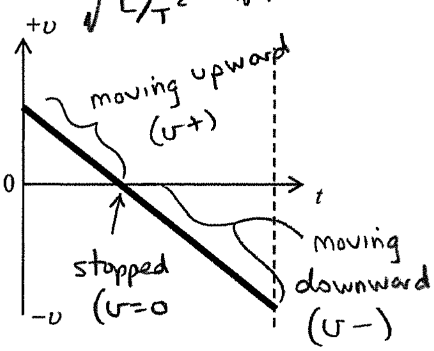
$\frac{L}{T^2}\cdot L = \frac{L^2}{T^2}$ X

$\sqrt{\frac{L}{L/T^2}} = \sqrt{T^2} = T$ X

A2. An elevator moves in a vertical elevator shaft. We choose the positive direction to be up. The graph shows the velocity of the elevator as a function of time. Which statement is correct for the time period shown?

E

(A) The elevator did not stop. F
(B) The elevator was at rest at time $t = 0$. F
(C) The elevator did not change direction. F
(D) The elevator was always going up. F
(E) At the end of the time period the elevator had a higher speed than at time $t = 0$. T



A3. A physics class in a lecture theatre has about 200 ($\sim 10^2$) students in it. What is an order-of-magnitude estimate of the total mass of students in the lecture theatre?

C

$m_{tot} = 10^2 \cdot 10^2\,kg = 10^4\,kg$

(A) 10^2 kg (B) 10^3 kg (C) 10^4 kg (D) 10^5 kg (E) 10^6 kg

order of magnitude estimate of mass of one student: 10^2 kg

A4. Two vehicles, a sports car and a truck, start from rest and accelerate with constant acceleration in a straight line along a track. The sports car has an acceleration with a magnitude that is four times the magnitude of the acceleration of the truck. The speed of the truck after travelling a distance d is V. What is the speed of the sports car after travelling the same distance d?

B

(A) $\sqrt{2}\,V$ (B) $2\,V$ (C) $4\,V$ (D) $8\,V$ (E) $16\,V$

$v^2 = v_0^2 + 2a\Delta x \Rightarrow v = \sqrt{2ad}$

A5. A stone is thrown straight up. Air resistance is negligible. Which one of the following statements is correct?

E

(A) During its flight there is a place where both its velocity and acceleration are zero. F
(B) During its flight the velocity and acceleration are always in the same direction. F
(C) During its flight the velocity is always in the opposite direction to the acceleration. F
(D) During its flight there is a place where the acceleration is zero but at no place is the velocity zero. F
(E) During its flight there is a place where the velocity is zero but at no place is the acceleration zero. T

for truck: $V = \sqrt{2a_T d}$

for car: $a_c = 4a_T$

$v_{f_c} = \sqrt{2a_c d} = \sqrt{2(4a_T)d}$

$v_{f_c} = \sqrt{8a_T d}$

$\therefore \frac{v_{f_c}}{V} = \frac{\sqrt{8a_T d}}{\sqrt{2a_T d}} = \sqrt{4} = 2$

$v_{f_c} = 2V$

continued on page 3...

A6. A student adds two vectors with magnitudes of 200 and 40. Which one of the following choices is a possible magnitude of the resultant? (All the other choices are impossible.)

B

(A) 100 (B) 200 (C) 260 (D) 40 (E) 50

opposite

The magnitude of the resultant ranges from 160 to 240

same direction

A7. A ball is kicked so that it leaves the ground at an angle of 60.0° with the horizontal. At what point in its flight is the magnitude of the acceleration of the ball equal to zero? You may ignore any effects due to air resistance.

E

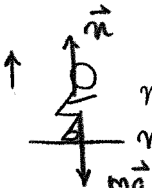
(A) Just after the ball leaves the kicker's foot
(B) Just before the ball hits the ground
(C) At the top of the trajectory
(D) When the ball is travelling at an angle of 45.0° with the horizontal
(E) Never

acceleration is g downward throughout the flight.

A8. As a basketball player starts to jump vertically, she begins to move upward faster and faster until she leaves the floor. During the time that she is in contact with the floor, the force of the floor on her shoes is

A

(A) greater than the magnitude of her weight and directed upward.
(B) greater than the magnitude of her weight and directed downward.
(C) less than the magnitude of her weight and directed upward.
(D) less than the magnitude of her weight and directed downward.
(E) exactly equal to the magnitude of her weight and directed upward.



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

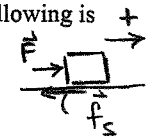
$n - mg = ma$

$n = m(a+g)$

To produce an upward acceleration, $n > mg$

A9. An object of mass m is sitting at rest on a flat, horizontal surface. The coefficients of static and kinetic friction between the object and the surface are μ_s and μ_k respectively. A horizontal force of magnitude F is now applied to the object, but it does not move. Which one of the following is the correct expression for the magnitude of the force of friction acting on the object?

E



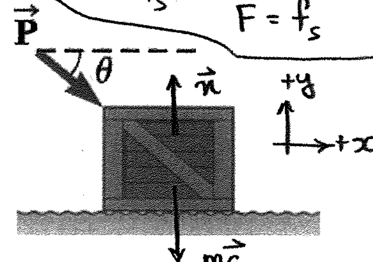
(A) $\mu_s mg$ (B) $\mu_k mg$ (C) $\mu_s F$ (D) $\mu_k F$ (E) F

object remains at rest so $\Sigma\vec{F} = 0 \Rightarrow F - f_s = 0$

$F = f_s$

A10. A crate of weight mg is pushed by a force P on a horizontal floor as shown in the figure. The coefficient of kinetic friction between the crate and the floor is μ_k and P is directed at an angle θ below the horizontal. Which one of the following is the correct expression for the normal force of the floor on the crate?

E



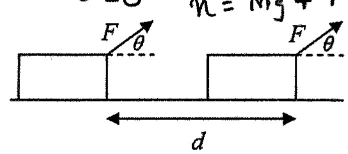
(A) $n = mg$ (B) $n = mg - P\cos\theta$
(C) $n = mg + P\cos\theta$ (D) $n = mg - P\sin\theta$
(E) $n = mg + P\sin\theta$

$\Sigma F_y = 0 \Rightarrow +n - mg - P\sin\theta = 0$

$n = mg + P\sin\theta$

A11. A block is being pulled a distance d across a rough horizontal surface by a rope that exerts a tension force F at an angle θ above the horizontal. The following table gives information about the work done on the block by the gravitational force (W_g), by the pulling force (W_F), by the normal force (W_n), and by the frictional force (W_f):
+ indicates positive work being done; – indicates negative work being done; and 0 indicates no work being done. Which row of the table is correct?

E



	W_g	W_F	W_n	W_f
(A)	+	–	–	0
(B)	–	+	+	–
(C)	0	+	+	–
(D)	0	–	0	+
(E)	0	+	0	–

$W = (F\cos\theta)d$

$\theta = 90°$ for gravitational and normal forces

The pulling force has a component in the direction of motion, so the pulling force does positive work.

$\theta = 180°$ for frictional force

Stu. No.: ____________________

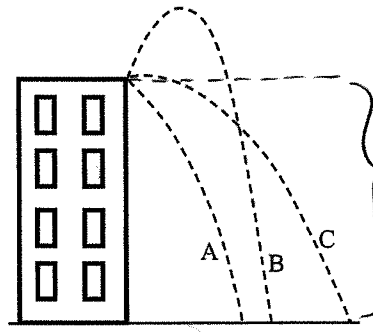
E

A12. The impulse experienced by a body is equivalent to its change in

(A) velocity. (B) mass. (C) kinetic energy. (D) potential energy. (E) momentum.

D

A13. A child throws water balloons from the top of a building. All the water balloons are thrown with the same speed but are launched at different angles. We can ignore air resisitance in the motion of the water balloons. For the three water balloons whose paths are shown in the diagram, compare the speeds with which the water balloons hit the ground below.



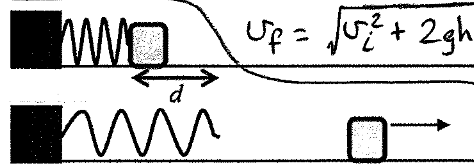
(A) Water balloon A hits with the highest speed.
(B) Water balloon B hits with the highest speed.
(C) Water balloon C hits with the highest speed.
(D) All three water balloons hit the ground with the same speed.
(E) We cannot answer this question without knowing the masses of the water balloons.

From cons. of mech. energy (no air resistance): $\frac{1}{2}mv_f^2 = \frac{1}{2}mv_i^2 + mgh$

$v_f = \sqrt{v_i^2 + 2gh}$ = same for all

A

A14. A Hooke's law spring is mounted horizontally over a frictionless surface. The spring is then compressed a distance *d* from its uncompressed length and is used to launch a mass *m* from rest along the frictionless surface. What compression distance of the spring would result in the mass attaining double the kinetic energy received in the above situation?



(A) $\sqrt{2}d$ (B) $2d$ (C) $2\sqrt{2}d$ (D) $4d$ (E) $8d$

frictionless ⇒ cons. of mech. energy: $KE_i + PE_i = KE_f + PE_f$

$0 + \frac{1}{2}kd^2 = KE_f$

$KE_f = \frac{1}{2}kd^2$

Situation 1

$KE_{f_1} = \frac{1}{2}kd_1^2$

Situation 2: $KE_{f_2} = 2KE_{f_1}$

and $KE_{f_2} = \frac{1}{2}kd_2^2$

$2KE_{f_1} = \frac{1}{2}kd_2^2$

$2(\frac{1}{2}kd_1^2) = \frac{1}{2}kd_2^2$

$2d_1^2 = d_2^2$

$d_2 = \sqrt{2}\cdot d_1 = \sqrt{2}\cdot d$

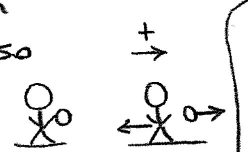
B

A15. A man, with mass *M*, standing at rest on a horizontal frictionless ice surface throws a ball, of mass *m*, horizontally. The ball is moving with speed *V* relative to the ice after it leaves the man's hand. What is the magnitude of the momentum of the man after he has thrown the ball?

(A) $\frac{M}{m}V$ (B) mV (C) MV (D) $\frac{m}{M}V$ (E) zero

No external forces on man/ball system, so

$\vec{P}_{tot_i} = \vec{P}_{tot_f}$



$0 = p_{man} + mV$

$|p_{man}| = |-mV|$

PART B

ANSWER <u>THREE</u> OF THE PART B QUESTIONS ON THE FOLLOWING PAGES AND <u>INDICATE YOUR CHOICES ON THE COVER PAGE</u>.

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.

<u>SHOW AND EXPLAIN YOUR WORK</u> – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.

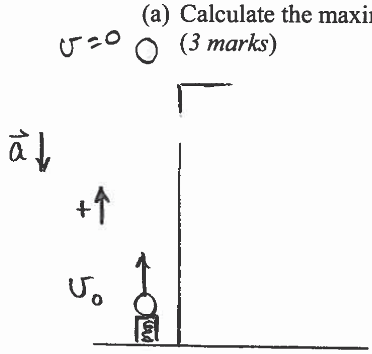
EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED.

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

continued on page 5...

B1. A pellet is shot vertically up from a spring gun next to a tall building. The initial speed of the pellet is 45.0 m/s. We can neglect air resistance in the motion of the pellet.

(a) Calculate the maximum height above the height of the spring gun that is reached by the pellet. (*3 marks*)



$v_{max} = 0$ at max. height

$a = -g$

$v_0 = +45.0\ m/s$

$\boxed{103\ m}$

$$v_{max}^2 = v_0^2 + 2a\,\Delta y$$

$$0 = v_0^2 + 2(-g)\Delta y$$

$$2g\Delta y = v_0^2$$

$$\Delta y = \frac{v_0^2}{2g} = \frac{(+45.0\ m/s)^2}{2(9.80\ m/s^2)} = 103\ m$$

(b) Calculate the time it takes for the pellet to reach that maximum height. (*3 marks*)

$\boxed{4.59\ s}$

$$v = v_0 + at$$

$$0 = v_0 - gt$$

$$gt = v_0$$

$$t = \frac{v_0}{g} = \frac{+45.0\ m/s}{9.80\ m/s^2} = 4.59\ s$$

(c) On its way down, the pellet passes a window in the building at a time of 6.20 s after it was shot. Calculate the height of the window above the height of the spring gun. (*4 marks*)

$\boxed{90.6\ m}$

$$\Delta y = v_0 t + \tfrac{1}{2}at^2$$

$$\Delta y = v_0 t + \tfrac{1}{2}(-g)t^2$$

$$\Delta y = (45.0\ m/s)(6.20\ s) - \tfrac{1}{2}(9.80\ m/s^2)(6.20\ s)^2$$

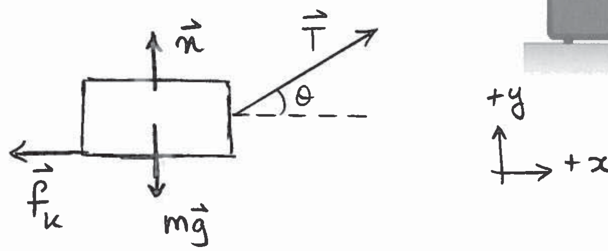
$$\Delta y = 90.6\ m$$

continued on page 6...

Stu. No.: ____________________

B2. A woman at an airport is towing her 20.0-kg suitcase at constant speed by pulling on a strap at an angle θ above the horizontal. She pulls on the strap with a 35.0-N force, and the friction force on the suitcase is 20.0 N.

(a) Draw a free-body diagram for the suitcase and show your choice of coordinate system. (*3 marks*)



(b) Calculate the angle that the strap makes with the horizontal. (*3 marks*)

linear motion at constant speed

$\Rightarrow \quad \Sigma \vec{F} = 0$

$\boxed{55.2°}$

$\Sigma F_x = 0$

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

$T\cos\theta = f_k$

$\cos\theta = \frac{f_k}{T} \qquad \theta = \text{invcos}\left(\frac{f_k}{T}\right) = \text{invcos}\left(\frac{20.0\text{N}}{35.0\text{N}}\right)$

$\theta = 55.2°$

(c) Calculate the magnitude of the normal force of the ground on the suitcase. If you did not obtain an answer for (b), use a value of 60.0°. (*4 marks*)

$\Sigma F_y = 0$

$\boxed{167\text{ N}}$

$+n + T\sin\theta - mg = 0$

$n = mg - T\sin\theta$

$n = (20.0\text{ kg})(9.80\text{ m/s}^2) - (35.0\text{N})(\sin 55.2°)$

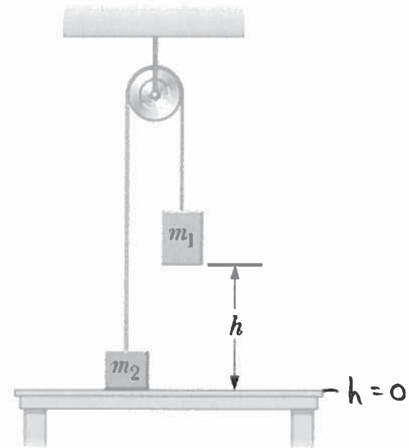
$n = 167\text{N}$

Alt: 166N

continued on page 7...

Stu. No.: ____________________

B3. All frictional effects may be ignored in this problem. Two objects of masses $m_1 = 5.00$ kg and $m_2 = 3.00$ kg are connected by a light string passing over a light, frictionless pulley as shown. m_1 is released from rest at a point $h = 4.00$ m above the table.



(a) Calculate the speed of each object just before m_1 hits the table. *(5 marks)*

$\boxed{4.43\ \text{m/s}}$

No frictional effects, so mechanical energy is conserved. ($W_{nc} = 0$)

$$E_i = E_f$$

$$KE_{1i} + PE_{1i} + KE_{2i} + PE_{2i} = KE_{1f} + PE_{1f} + KE_{2f} + PE_{2f}$$

$$m_1 g h = \frac{1}{2} m_1 v_f^2 + 0 + \frac{1}{2} m_2 v_f^2 + m_2 g h$$

$$(m_1 - m_2) g h = \frac{1}{2}(m_1 + m_2) v_f^2$$

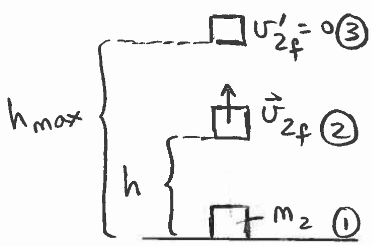
$$v_f = \sqrt{\frac{2(m_1 - m_2) g h}{(m_1 + m_2)}}$$

$$v_f = \sqrt{\frac{2(5.00\,\text{kg} - 3.00\,\text{kg})(9.80\,\text{m/s}^2)(4.00\,\text{m})}{(5.00\,\text{kg} + 3.00\,\text{kg})}} = 4.43\,\text{m/s}$$

(b) How much higher does m_2 travel after m_1 hits the table? If you did not obtain an answer for (b), use a value of 4.50 m/s. *(5 marks)*

$\boxed{1.00\ \text{m}}$

When m_2 reaches the top of its trajectory, $v'_{2f} = 0$



Mech. energy is still conserved for m_2.

$$E_{②} = E_{③}$$

$$m_2 g h + \frac{1}{2} m_2 v_{2f}^2 = m_2 g h_{max}$$

$$\frac{1}{2} v_{2f}^2 = g(h_{max} - h)$$

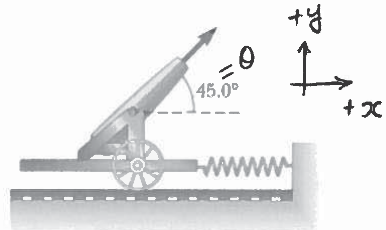
$$h_{max} - h = \frac{v_{2f}^2}{2g} = \frac{(4.43\,\text{m/s})^2}{2(9.80\,\text{m/s}^2)} = 1.00\,\text{m}$$

Alt: 1.03 m

continued on page 8...

Stu. No.: ____________________

B4. A cannon is rigidly attached to a carriage, which can move along horizontal rails, but is connected to a post by a large spring, initially unstretched and with spring constant $k = 2.00 \times 10^4$ N/m. The combined mass of the cannon and carriage is 5.00×10^3 kg. The cannon fires a 200-kg projectile at a velocity of 125 m/s directed 45.0° above the horizontal.



(a) Calculate the recoil speed of the cannon. (*4 marks*)

$\boxed{3.54 \text{ m/s}}$

Consider the cannon-carriage-projectile system. Assuming that the firing of the projectile occurs in a very short period of time, before the spring has stretched, momentum is conserved in the x-direction. Momentum is not conserved in the y-direction because of the gravitational and normal forces that are external to the system ($n \neq mg$ during firing).

$$\vec{p}_{f_x} = \vec{p}_{i_x} \Rightarrow m_p v_{p_{fx}} + m_c v_{f_c} = 0$$

$$m_p v_{p_f} \cos\theta + m_c v_{f_c} = 0$$

to left

$$v_{f_c} = -\frac{m_p v_{p_f} \cos\theta}{m_c} = \frac{-(200 \text{ kg})(125 \text{ m/s})\cos 45.0°}{5.00 \times 10^3 \text{ kg}} = -3.54 \text{ m/s}$$

(b) Calculate the maximum extension of the spring. If you did not obtain an answer for (a), use a value of 3.50 m/s. (*3 marks*)

$\boxed{1.77 \text{ m}}$

After the projectile has been fired, $W_{nc} = 0$ so mechanical energy is conserved for the cannon/carriage/spring.

$$E_f = E_i \Rightarrow KE_f + PE_f = KE_i + PE_i$$

$$0 + \tfrac{1}{2}kx_{max}^2 = \tfrac{1}{2}m_c v_{f_c}^2 + 0$$

(no change in PE_{grav} b/c cannon moves horizontally)

$$x_{max} = v_{f_c}\sqrt{\frac{m_c}{k}}$$

$$x_{max} = 3.54 \text{ m/s}\sqrt{\frac{5.00 \times 10^3 \text{ kg}}{2.00 \times 10^4 \text{ N/m}}} = 1.77 \text{ m}$$

(c) Calculate the magnitude of the maximum force exerted on the carriage by the spring. If you did not obtain an answer for (b), use a value of 1.80 m. (*3 marks*)

$\boxed{3.54 \times 10^4 \text{ N}}$

Maximum spring force corresponds to maximum spring stretch:

$$\vec{F} = -k\vec{x}$$

$$F = kx = (2.00 \times 10^4 \text{ N/m})(1.77 \text{ m}) = 3.54 \times 10^4 \text{ N}$$

END OF EXAMINATION