UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

Physics 115.3

MIDTERM EXAM – Alternative Sitting

October 2017 Time: 90 minutes

NAME: SOLUTIONS MASTER STUDENT NO.: ____________

(Last) **Please Print** (Given)

LECTURE SECTION (please check):

- ❑ 01 Dr. D. Janzen
- ❑ 02 Dr. R. Pywell
- ❑ 03 B. Zulkoskey
- ❑ 97 Dr. A. Farahani
- ❑ C15 Dr. A. Farahani

INSTRUCTIONS:

1. This is a closed book exam.
2. The test package includes a test paper (this document), an exam booklet, a formula sheet, a scratch card 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 name on the exam booklet and scratch card.
5. Enter your name and NSID on the OMR sheet.
6. The test paper, the exam booklet, the formula sheet, the scratch card, and the OMR sheet must all be submitted.
7. No test materials will be returned.

QUESTION NUMBER	MAXIMUM MARKS	MARKS OBTAINED
A1-12	12	
B1-4	8	
B5-8	8	
B9-12	8	
B13-16	8	
MARK	out of 36:	

PART A

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

B

A1. Vector $\vec{A}$ has horizontal and vertical components of 2.0 cm and 1.5 cm respectively. Vector $\vec{B}$ has horizontal and vertical components of 2.0 cm and −1.5 cm respectively. The vector $\vec{C} = \vec{A} + \vec{B}$ has a magnitude of… $C_x = A_x + B_x = 2.0\text{cm} + 2.0\text{cm} = 4.0\text{cm}$

(A) 3.0 cm. (B) 4.0 cm. (C) 5.0 cm. (D) 8.0 cm. (E) 16 cm.

$C_y = A_y + B_y = 1.5\text{cm} + (-1.5\text{cm}) = 0$

B

A2. You measure the length and width of a rectangle with a ruler and you arrive at the values 1.245 m and 0.344 m respectively. You calculate the rectangle's perimeter with your calculator by adding the length and width and then multiplying the result by 2. The calculator display reads "3.1780". Wishing to express your answer to the proper number of significant figures, you should record your answer for the perimeter as… $P = 2(l+w) = 2(1.245\text{m} + 0.344\text{m})$

(A) 3.1780 m. (B) 3.178 m. (C) 3.18 m. (D) 3.2 m. (E) 3.0 m. $= 2(1.589\text{m}) = 3.178\text{m}$

A

A3. Given the following dimensions for the quantities H, v_0, and g: $[H] = L$; $[v_0] = L/T$; $[g] = L/T^2$, which one of the following equations is dimensionally correct?

(A) $H = \frac{v_0^2}{2g}\sin^2\theta$ (B) $H = \frac{v_0}{2g}\sin^2\theta$ (C) $H = \sqrt{\frac{v_0}{2g}\sin^2\theta}$

(D) $H = \frac{g}{2v_0}\sin^2\theta$ (E) $H = \frac{gv_0}{2}\sin^2\theta$ $\frac{(L/T)^2}{L/T^2} = \frac{L^2/T^2}{L/T^2} = \frac{L^2}{L} = L$ ✓

C

A4. A skateboarder starts from rest and moves down a hill with constant acceleration in a straight line, travelling for 6 s. In a second trial, he starts from rest and moves along the same straight line with the same acceleration for only 2 s. How does his displacement from his starting point in this second trial compare with the first trial? $\Delta x = v_0 t + \frac{1}{2}at^2 = 0 + \frac{1}{2}at^2 \Rightarrow \Delta x \propto t^2$

(A) one-third as large (B) three times larger (C) one-ninth as large

(D) nine times larger (E) $1/\sqrt{3}$ times as large $\frac{\Delta x_2}{\Delta x_1} = \frac{t_2^2}{t_1^2} = \frac{(2s)^2}{(6s)^2} = \left(\frac{1}{3}\right)^2 = \frac{1}{9}$

B

A5. A sailor drops a wrench from the top of a sailboat's vertical mast, a vertical distance of 10.0 m above the deck of the boat, while the boat is moving with constant velocity. Where will the wrench hit the deck? Ignore any effects due to air resistance.

(A) The wrench will hit the deck ahead of the base of the mast.
(B) The wrench will hit the deck at the base of the mast.
(C) The wrench will hit the deck behind the base of the mast.
(D) The answer depends on the mass of the wrench.
(E) The answer depends on the speed of the boat.

constant velocity $\Rightarrow \Sigma F = 0$ for sailboat.

Net force on wrench is only the vertical gravitational force.

∴ Horizontal motions of wrench and sailboat are the same.

D

A6. A blue ball is thrown horizontally from the roof of a building and at exactly the same time a green ball is dropped from rest. You may assume that the building and the ground around it are level and that air resistance effects are negligible. Which ball reaches the ground first, and what can be said about their speeds on impact? Vertical motions are the same ($v_{oy} = 0$, $a_y = g$ down) so times are the same. Blue ball is always moving faster than green ball.

(A) The blue ball reaches the ground first and it is moving faster than the green ball throughout its motion.
(B) The green ball reaches the ground first and it is moving faster than the blue ball throughout its motion.
(C) Both balls reach the ground at the same time, and with the same speed.
(D) Both balls reach the ground at the same time, and the blue ball is moving faster on impact.
(E) The answer depends on the masses of the balls.

E

A7. If a constant non-zero net force acts on an object during a given period of time, which one of the following statements **must** be true during that time?

(A) The object does not move.
(B) The acceleration of the object is increasing.
(C) The object's speed remains constant.
(D) The magnitude of the object's velocity increases.
(E) The object accelerates.

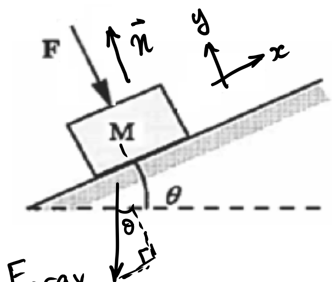
$\Sigma\vec{F} \neq 0 \Rightarrow \vec{a} \neq 0 \Rightarrow$ changing velocity

changing velocity $\Rightarrow$ change in speed or change in direction or change in both speed and direction

Constant net force $\Rightarrow$ constant acceleration

B

A8. A block of mass M is on an inclined surface that makes an angle θ with the horizontal. A force $\vec{F}$, perpendicular to the surface, acts on the block as shown in the figure. Which one of the following is the correct expression for the magnitude of the normal force of the surface of the incline on the block?



(A) $Mg\cos\theta$ (B) $F + Mg\cos\theta$ (C) $F - Mg\cos\theta$
(D) $Mg\cos\theta + F\cos\theta$ (E) $Mg\cos\theta - F\cos\theta$

$\Sigma F_y = 0$

$+n - F - mg\cos\theta = 0 \Rightarrow n = F + mg\cos\theta$

E

A9. Two objects, 1 and 2, with masses $m_1 = m$ and $m_2 = 2m$, respectively, are initially positioned so that their centres are a distance r apart. The magnitude of the gravitational force of object 2 on object 1 is F. Object 2 is now replaced with object 3, of mass $m_3 = 4m$, and it is positioned so that its centre is a distance $2r$ from the centre of object 1. The magnitude of the gravitational force of object 1 on object 3 is…

$F_{21} = \frac{G(m)(2m)}{r^2} = 2\frac{Gm^2}{r^2}$; $F_{13} = G\frac{(m)(4m)}{(2r)^2} = \frac{Gm^2}{r^2} = \frac{1}{2}(F_{21}) = \frac{1}{2}F$

(A) F. (B) $2F$. (C) $4F$. (D) ¼ F. (E) ½ F.

D

A10. A car has a mass m and is moving with speed V. A truck has a mass $2m$ and is moving with speed $2V$. Which equation correctly relates the kinetic energy of the truck, KE_{truck}, to the kinetic energy of the car, KE_{car}?

(A) $KE_{truck} = KE_{car}$ (B) $KE_{truck} = 2KE_{car}$ (C) $KE_{truck} = 4KE_{car}$.
(D) $KE_{truck} = 8KE_{car}$ (E) $KE_{truck} = 16KE_{car}$

$KE_{truck} = \frac{1}{2}(2m)(2v)^2 = \frac{1}{2}(2m)(4V^2) = \frac{1}{2}(8mV^2)$

$KE_{truck} = 8\left(\frac{1}{2}mV^2\right) = 8\,KE_{car}$

A11. A box, of mass *m*, resting stationary on the floor, is lifted up and put on a table top where it then remains stationary. The table top is a height *h* above the floor. What is the net work done on the box during this process? Ignore any effects due to air resistance.

D $W_{net} = \Delta KE = 0$

(A) *mgh* (B) *mg* (C) –*mgh* (D) zero

(E) The net work cannot be determined without knowing the details of how fast the box was moved and what path it took.

A12. You hold a slingshot at arm's length, pull the light elastic band back to your chin, and release it to launch a pebble horizontally with speed 200 cm/s. With the same procedure, you fire a bean with speed 600 cm/s. What is the ratio of the mass of the bean to the mass of the pebble?

A

(A) 1/9 (B) 1/3 (C) 1 (D) 3 (E) 9

In both cases, the work done by the elastic band is the same.

$\therefore W_{\text{elastic band}} = \Delta KE_{pebble} = \Delta KE_{bean}$

$\therefore \frac{1}{2} m_p v_p^2 = \frac{1}{2} m_b v_b^2$

$\frac{m_b}{m_p} = \left(\frac{v_p}{v_b}\right)^2 = \left(\frac{200\text{cm/s}}{600\text{cm/s}}\right)^2 = \left(\frac{1}{3}\right)^2 = \frac{1}{9}$

PART B

WORK OUT THE ANSWERS TO THE FOLLOWING PART B QUESTIONS.

WHEN YOU HAVE AN ANSWER THAT IS ONE OF THE OPTIONS AND ARE CONFIDENT THAT YOUR METHOD IS CORRECT, SCRATCH THAT OPTION ON THE SCRATCH CARD. IF YOU REVEAL A STAR ON THE SCRATCH CARD THEN YOUR ANSWER IS CORRECT (FULL MARKS, 2/2).

IF YOU DO NOT REVEAL A STAR WITH YOUR FIRST SCRATCH, TRY TO FIND THE ERROR IN YOUR SOLUTION. IF YOU REVEAL A STAR WITH YOUR SECOND SCRATCH, YOU RECEIVE HALF-MARKS (1/2).

IF YOU STILL DO NOT HAVE THE CORRECT ANSWER, BUT REWORK YOUR SOLUTION AND REVEAL A STAR WITH YOUR THIRD SCRATCH, THEN YOU RECEIVE 0.2/2.

REVEALING THE STAR WITH YOUR FOURTH OR FIFTH SCRATCHES DOES NOT EARN YOU ANY MARKS, BUT IT DOES GIVE YOU THE CORRECT ANSWER.

YOU MAY ANSWER ALL FOUR PART B QUESTION GROUPINGS (1-4, 5-8, 9-12, AND 13-16) AND YOU WILL RECEIVE THE MARKS FOR YOUR BEST 3 GROUPINGS.

USE THE PROVIDED EXAM BOOKLET FOR YOUR ROUGH WORK.

Grouping B1-B4

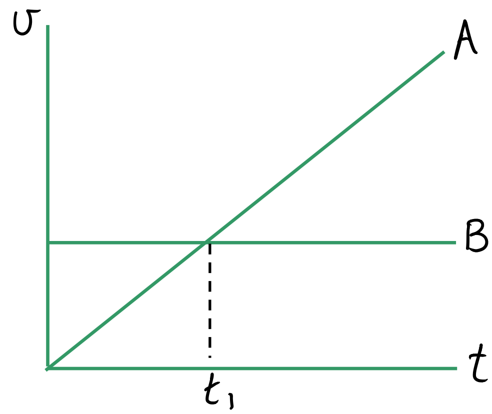
Cyclist A is stopped by the side of the road. She starts to accelerate from rest at the instant that she is passed by cyclist B, who is moving at a constant velocity of v_B. Cyclist A maintains a constant acceleration, a_A, and eventually overtakes cyclist B.

B1. At the instant that cyclist A overtakes cyclist B, how is her speed, v_A, related to the speed of cyclist B?

At instant of overtaking, $\Delta x_A = \Delta x_B \Rightarrow \frac{1}{2}(0+v_A)t = \frac{1}{2}(v_B+v_B)t$

$\frac{1}{2}v_A = v_B \Rightarrow v_A = 2v_B$

B2. Given that the following graph correctly shows the velocities of the cyclists as functions of time, how does the time t_{AB}, when cyclist A overtakes cyclist B, relate to the time t_1 indicated on the graph?



t_1 is time when $v_A = v_B$

Since, from B1, t_{AB} is time when $v_A = 2v_B$, and cyclist A has constant acceleration,

$t_1 = \frac{1}{2}t_{AB}$

$\therefore t_{AB} = 2t_1$

B3. The constant velocity of cyclist B is 7.00 m/s and the constant acceleration of cyclist A is 0.500 m/s^2. Calculate the time required for cyclist A to overtake cyclist B.

$$\Delta x_A = \Delta x_B \Rightarrow v_{0A}t + \frac{1}{2}a_A t^2 = v_{0B}t + \frac{1}{2}a_B t^2 \Rightarrow \frac{1}{2}a_A t^2 = v_{0B}t$$

$$t = \frac{2v_{0B}}{a_A} = \frac{2(7.00\,\text{m/s})}{0.500\,\text{m/s}^2} = \boxed{28.0\,\text{s}}$$

B4. How far has cyclist A ridden when she overtakes cyclist B?

$$\Delta x_A = \frac{1}{2}a_A t^2 = \frac{1}{2}(0.500\,\text{m/s}^2)(28.0\,\text{s})^2 = \boxed{196\,\text{m}}$$

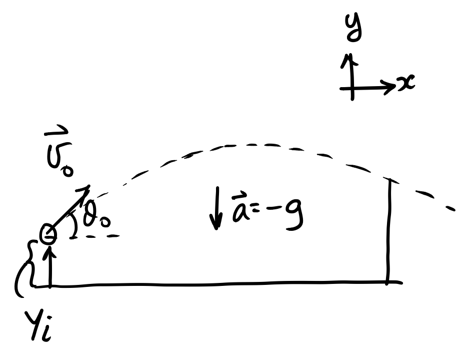
Grouping B5-B8

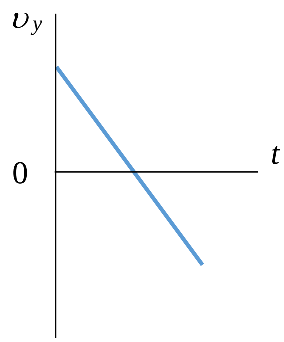
A baseball player at Boston's Fenway Park hits a ball from a height of 1.15 m above the ground, with an initial velocity of v_0 = 38.0 m/s at an angle of θ_0 = 55.0° above the horizontal. Assume air resistance is negligible. The ball travels toward a wall.

B5. Which one of the following is the correct expression for the speed of the ball when it reaches maximum height?

At max. height, $v = v_x = v_{0x} = v_0 \cos\theta_0$

B6. Which one of the following velocity versus time graphs best describes the vertical motion of the ball from the moment it is hit until just before it hits the wall or ground? (UP is positive)





a_y is constant and −ve. $\therefore$ v_y vs t is linear with a −ve slope. v_y starts +ve, becomes 0 at max. height, then becomes increasingly negative.

B7. The ball is hit towards left field, where it needs to clear an 11.33 m wall if the hit would be a home run. How long after the ball is hit will it take before it drops down to a height of 11.33 m above the ground?

$\Delta y = v_{0y} t + \frac{1}{2} a_y t^2 \Rightarrow (y_f - y_i) = (v_0 \sin\theta_0) t - \frac{1}{2} g t^2$

$\frac{1}{2} g t^2 - (v_0 \sin\theta_0) t + (y_f - y_i) = 0 \Rightarrow (4.90\,m/s^2) t^2 - (31.13\,m/s) t + (11.33\,m - 1.15\,m) = 0$

$t = \frac{31.13 \pm \sqrt{(31.13)^2 - 4(4.90)(10.18)}}{9.80}\,s = \frac{31.13 \pm 27.74}{9.80}\,s = 6.01\,s$ (on the way down) or $0.346\,s$ (on the way up)

B8. Is it a home run? The left field wall at Fenway Park is 94.5 m from home plate, and the ball needs to travel at least this far before it drops to 11.33 m above the ground for a home run to have occurred. What is the horizontal distance travelled by the ball over the time interval in B7?

$\Delta x = v_x t = (v_0 \cos\theta_0) t = (38.0\,m/s)(\cos 55.0°)(6.01\,s) = 131\,m$

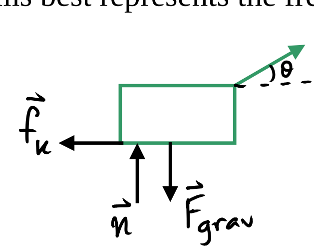
Grouping B9-B12

A crate of mass m is being dragged across the floor by means of an attached rope. The tension in the rope has a magnitude of T and the rope is at an angle of θ above the horizontal. f_k is the magnitude of the kinetic friction force between the crate and the floor and the coefficient of kinetic friction between the crate and the floor is μ_k.

B9. Which one of the following expressions is correct for the net horizontal force on the crate?

$T\cos\theta - f_k$

B10. Which one of the following diagrams best represents the free-body diagram for the crate?



$\sum F_y = 0$

$n + T\sin\theta - F_{grav} = 0$

$n = F_{grav} - T\sin\theta$

$n = mg - T\sin\theta$

Let m = 33.0 kg, θ = 26.0°, T = 195 N, and μ_k = 0.420.

B11. Calculate the magnitude of the normal force of the floor on the crate.

$n = mg - T\sin\theta$

$n = (33.0\,\text{kg})(9.80\,\text{m/s}^2) - 195\,\text{N}\sin(26.0°)$

$n = 238\,\text{N}$

B12. Calculate the magnitude of the acceleration of the crate.

$\sum F_x = ma \Rightarrow T\cos\theta - f_k = ma \Rightarrow T\cos\theta - \mu_k n = ma$

$$a = \frac{T\cos\theta - \mu_k n}{m} = \frac{195\,\text{N}\cos(26.0°) - 0.420(238\,\text{N})}{33.0\,\text{kg}} = 2.28\,\text{m/s}^2$$

Grouping B13-B16

A man on a sled with a total mass of m = 125 kg starts from rest and slides down a snow-covered slope which makes a constant angle of θ = 30.0° with the horizontal. Assume that the slope is d = 50.0 m long and the coefficient of kinetic friction between the sled and the snow is μ_k = 0.260.

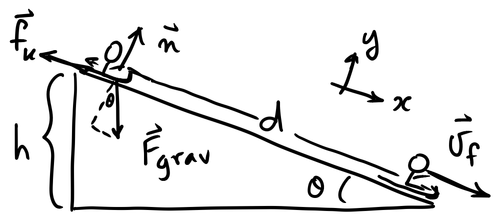
B13. Which one of the following is the correct expression for the work done by gravity as the man and sled move the distance d?

$$W_{grav} = -\Delta PE_{grav} = -(PE_{grav_f} - PE_{grav_i}) = -(0 - mgh) = mgh = mgd\sin\theta$$ (see diagram below)

B14. Which one of the following is the correct expression for the work done by friction as the man and sled move the distance d?

$$W_{fr} = f_k \cos(180°) d = \mu_k n(-1)(d) = -\mu_k mg\cos\theta \cdot d = -\mu_k mgd\cos\theta$$ (see B15)

B15. Calculate the speed of the man and sled at the bottom of the slope.



$$\Sigma F_y = 0$$
$$+n - mg\cos\theta = 0$$
$$n = mg\cos\theta$$

$$E_i + W_{nc} = E_f \Rightarrow KE_i + PE_i + W_{fr} = KE_f + PE_f$$
$$0 + mgd\sin\theta - \mu_k mgd\cos\theta = \frac{1}{2}mv_f^2$$
$$v_f = \sqrt{2gd(\sin\theta - \mu_k\cos\theta)}$$
$$v_f = \{2(9.80\,m/s^2)(50.0\,m)[\sin(30.0°) - 0.260\cos(30.0°)]\}^{1/2}$$
$$v_f = 16.4\,m/s$$

B16. After reaching the bottom of the slope, the man and sled slide on a snow-covered horizontal surface. Calculate the horizontal distance they slide before coming to rest. The coefficient of kinetic friction between the sled and snow is still 0.260.

Once the sled is moving horizontally, $n = mg$

$$\Sigma F_x = ma \Rightarrow -f_k = ma \Rightarrow -\mu_k n = ma \Rightarrow -\mu_k mg = ma \Rightarrow a = -\mu_k g$$
$$v^2 = v_0^2 + 2a\Delta x \Rightarrow \Delta x = \frac{v^2 - v_0^2}{2a} = \frac{0 - (16.4\,m/s)^2}{2(-0.260)(9.80\,m/s^2)} = 52.8\,m$$

ALT. SOLUTION:

$$E_i + W_{nc} = E_f \Rightarrow \frac{1}{2}mv^2 + (f_k\cos 180°)d = 0 \Rightarrow \frac{1}{2}mv^2 - \mu_k mgd = 0$$
$$d = \frac{v^2}{2\mu_k g} = \frac{(16.4\,m/s)^2}{2(0.260)(9.80\,m/s^2)}$$
$$d = 52.8\,m$$

END OF EXAMINATION