UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 115.3
MIDTERM TEST

October 22, 2008 Time: 90 minutes

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

STUDENT NO.: ____________

LECTURE SECTION (please check):

- ❑ 01 B. Zulkoskey
- ❑ 02 Dr. C. Mitchell
- ❑ 03 Dr. A. Robinson
- ❑ 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 7 pages. **It is the responsibility of the student to check that the test paper is complete.**
3. Only Hewlett-Packard 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 to 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 test paper will be returned. The formula sheet and the OMR sheet will NOT be returned.

PLEASE DO NOT WRITE ANYTHING ON THIS TABLE

QUESTION NO.	MAXIMUM MARKS	MARKS OBTAINED
Part A	15	
B1	10	
B2	10	
B3	10	
TOTAL	45	

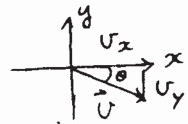
continued on page 2...

PART A

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

A

A1. Vector $\vec{v}$ has a magnitude of 4.5 m/s and a direction 24° below the positive x-axis. Assume that the positive x-axis points to the right and the positive y-axis points upwards. What are the x and y components of $\vec{v}$?



(A) $v_x = +4.1$ m/s, $v_y = -1.8$ m/s (B) $v_x = +3.1$ m/s, $v_y = +2.2$ m/s
(C) $v_x = +2.0$ m/s, $v_y = -3.7$ m/s (D) $v_x = +2.0$ m/s, $v_y = -3.1$ m/s
(E) $v_x = -1.8$ m/s, $v_y = -3.1$ m/s

$v_x = +v\cos\theta$; $v_y = -v\sin\theta$

B

A2. Zero net force is applied to an object which is moving with a positive velocity in the x direction. Which one of the following statements is **true**?

$\sum \vec{F} = 0 \Rightarrow \vec{a} = 0 \Rightarrow \vec{v}$ constant

(A) There are no forces applied to the object.
(B) The object's velocity remains constant.
(C) The object's velocity gradually decreases in magnitude.
(D) The object stops.
(E) The object will slow down if there is a frictional force acting on it.

$F_{grav} = \dfrac{Gm_1m_2}{r^2}$

A

A3. Mars' biggest moon, Phobos, orbits Mars at a distance from the centre of Mars of approximately 9400 km. If this distance was increased by a factor of 2.5, by what factor would the gravitational force of Mars on Phobos change? $r_2 = 2.5r_1$

(A) 0.16 (B) 2.5 (C) 6.2 (D) 0.40 (E) 0.30

$\dfrac{F_2}{F_1} = \dfrac{Gm_1m_2/r_2^2}{Gm_1m_2/r_1^2}$

$\dfrac{F_2}{F_1} = \dfrac{r_1^2}{r_2^2}$

$\dfrac{F_2}{F_1} = \dfrac{r_1^2}{(2.5r_1)^2}$

C

A4. The magnitude of the force F exerted by a spring that is stretched a distance x is given by the equation $F = kx$. Letting [M] represent the dimension of mass, [L] represent the dimension of length, and [T] represent the dimension of time, the constant k has the dimensions

(A) [M] / [L] (B) [M][L] (C) [M] / $[T]^2$ (D) [L] / [T] (E) $[M][L]^2 / [T]^2$

$[k] = [F]/[x] = [M][L]/[T]^2/[L] = [M]/[T]^2$

D

A5. A man who weighs 600 N is sitting in a chair with his feet on the floor and arms resting on the armrests. The chair weighs 100 N. Each armrest exerts an upward force of 25 N on his arms and the seat exerts an upward force on him of 500 N. What force does the floor exert on his feet?

$\sum F = 0$

(A) 75 N upward (B) 500 N upward (C) 525 N upward
(D) 50 N upward (E) 0 N

$\uparrow +$ $-F_{grav} + F_{arm} + F_{arm} + F_{seat} + F_{floor} = 0$

$F_{floor} = 600\text{N} - 25\text{N} - 25\text{N} - 500\text{N} = 50\text{N}$

D

A6. An object is thrown vertically upward. Which one of the following statements is **false**?

(A) When the object is moving upwards, the velocity vector and the acceleration vector are in opposite directions. T
(B) When the object is moving downwards, the velocity vector and the acceleration vector are in the same direction. T
(C) At the top of the trajectory, the velocity vector is zero. T
(D) At the top of the trajectory, the acceleration vector is zero. F
(E) If the object returns to the position from which it was thrown, the displacement vector is zero. T

C

A7. Two children are standing at the edge of a cliff. One child throws a stone horizontally into the canyon. At the same time, the other child drops a stone over the edge. Neglecting air resistance, which one of the following statements is **true**?

time depends on vertical motion and both stones have the same vertical components of motion.

(A) The thrown stone hits the ground first.
(B) The dropped stone hits the ground first.
(C) Both stones hit the ground at the same time.
(D) Which stone hits first depends on the speed of the thrown stone.
(E) Which stone hits first depends on the height of the cliff above the canyon floor.

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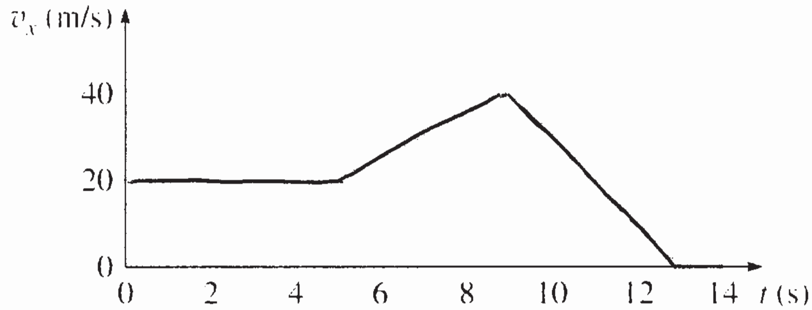
A8. Which one of the following statements concerning the velocity versus time graph below is **false**?

B



(A) In the time interval from 0 to 5 seconds, the velocity is constant. T
(B) The position at time $t = 0$ s and the position at time $t = 14$ s must be identical. F
(C) The acceleration is positive in the time interval 5 to 9 seconds. T
(D) The position vectors at t = 13 seconds and t = 14 seconds are the same. T
(E) The acceleration is negative in the time interval 9 to 13 seconds. T

A9. Consider a spaceship in deep space, where the force of gravity is negligible. Which one of the following phrases best completes the sentence, "The spaceship's engines must be fired…"

E

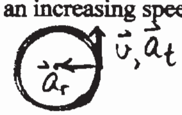
(A) all the time in order to keep moving. Newton's First Law
(B) **only** when the spaceship changes direction.
(C) **only** when the spaceship changes speed.
(D) **only** when the spaceship increases its speed.
(E) whenever the spaceship speeds up, slows down, or changes direction.

A10. A student is riding her motorcycle in a straight line. The initial position is –125 m and the initial velocity is –35.0 km/h. Her final velocity is 0 km/h and final position is –173 m. Which one of the following statements is **false**?

C

(A) Her average velocity is negative. T
(B) Her displacement is negative. T
(C) Her average acceleration is negative. F
(D) She is slowing down. T
(E) The distance travelled is 48 m. T

A11. An object moves along a circular path with an increasing speed. The total acceleration of the object is directed



C

(A) radially inward.
(B) radially outward.
(C) with a component radially inward and a component along the direction of the velocity.
(D) with a component radially inward and a component opposite to the direction of the velocity.
(E) with a component radially outward and a component along the direction of the velocity.

A12. Consider a frictionless dart gun that uses an ideal spring to propel the dart. The mass of the dart is m, the spring constant is k and the spring is compressed a distance x when the gun is loaded. When the gun is held horizontally and fired, the speed of the dart when it leaves the barrel of the gun is given by:

D

(A) $\frac{kx}{m}$ (B) $2\frac{kx}{m}$ (C) $\frac{kx}{2m}$ (D) $\sqrt{\frac{k}{m}}x$ (E) $\sqrt{\frac{2k}{m}}x$

$W_{nc} = 0$

$K_i + U_i = K_f + U_f$

$0 + \frac{1}{2}kx^2 = \frac{1}{2}mv_f^2 + 0$

$v_f = \sqrt{\frac{k}{m}} \cdot x$

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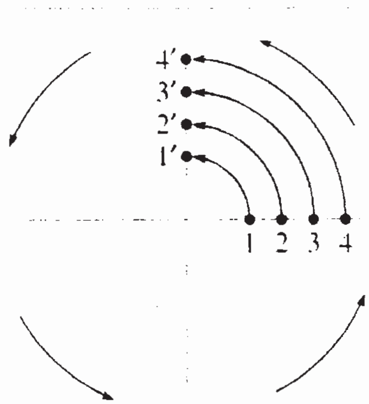
A13. Consider the rotating CD shown in the figure.



C

Which one of the following statements is **false**?

(A) The angular speeds of the points 1, 2, 3 and 4 are equal. T
(B) The linear speed is proportional to the distance from the centre of rotation. T $v = r|\omega|$
(C) The linear speed is greater nearer the centre of rotation. F
(D) The angular displacement of point 1 moving to point 1′ is $+\frac{\pi}{2}$ radians. T
(E) An acceptable unit for the angular velocity is rad/s. T

A14. A wheel is rolling without slipping. It has radius r and a period of rotation of T. What is the linear speed v, of the wheel?

B

(A) $v = \frac{r}{T}$ (B) $v = \frac{2\pi r}{T}$ (C) $v = \frac{2\pi}{rT}$ (D) $v = \frac{T}{2\pi r}$ (E) $v = \frac{r}{2\pi T}$

A15. Which one of the following statements is **false**?

D

(A) Energy stored as potential energy by a conservative force during displacement can be recovered as kinetic energy. T
(B) A force is conservative if the work done by the force is independent of the path taken. T
(C) Gravity is a conservative force. T
(D) Friction is a conservative force. F
(E) If a system is acted upon only by conservative forces, then the total mechanical energy of the system is constant. T

PART B

IN EACH OF THE FOLLOWING QUESTIONS, 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.

NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY, SHOW AND EXPLAIN YOUR WORK.
EQUATIONS NOT PROVIDED ON THE FORMULA SHEET MUST BE DERIVED.

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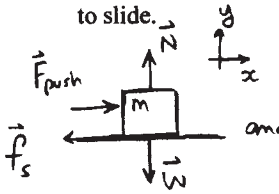
Stu. No.: ____________________

B1. You wish to slide your Yamaha baby grand piano a small distance along the floor. The piano has a mass of 249 kg, the coefficient of static friction between the piano and the floor is 0.300 and the coefficient of kinetic friction between the piano and the floor is 0.200. You and a few friends push horizontally on the piano and slowly increase the applied force. *Remember to include a free body diagram and choice of coordinates for each of the following parts.*

(a) Calculate the magnitude of the applied horizontal force at the instant that the piano starts to slide.



When the piano just starts to slide, $f_s = f_{s,max} = \mu_s N$ and $\sum \vec{F} = 0$

$\boxed{732\text{ N}}$

$\sum F_x = 0$

$F_{push} - f_{s,max} = 0$

$F_{push} = f_{s,max}$

$F_{push} = \mu_s N$

$\sum F_y = 0$

$N - W = 0$

$N = W$

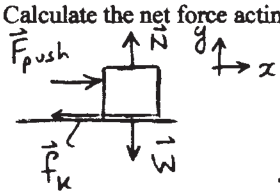
$N = mg$

$F_{push} = \mu_s mg$

$F_{push} = (0.300)(249\text{ kg})(9.80\text{ m/s}^2)$

$F_{push} = 732\text{ N}$

(b) Once the piano starts to slide, the applied horizontal force is changed to 5.50×10^2 N. Calculate the net force acting on the piano as it is sliding.



$\boxed{62.0\text{ N}}$

$\sum F_y = 0$

$N - W = 0 \Rightarrow N = W = mg$

$\sum \vec{F} = \sum F_x = F_{push} - f_k$

$\sum F_x = F_{push} - \mu_k N$

$\sum F_x = F_{push} - \mu_k mg$

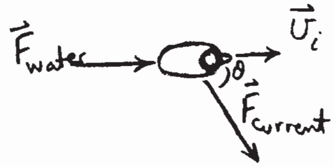
$\sum F_x = 5.50 \times 10^2\text{ N} - (0.200)(249\text{ kg})(9.80\text{ m/s}^2)$

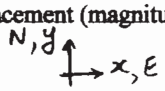
$\sum F_x = 62.0\text{ N}$

Stu. No.: ____________________

B2. A duck has a mass of 2.50 kg. There are two forces acting on the duck: a force of 0.100 N due East (caused by the water reacting to the duck's paddling) and a force of 0.200 N in a direction of 52.0° South of East due to the current. The duck has an initial velocity of 0.110 m/s due East.

(a) Calculate the displacement (magnitude and direction) of the duck in a time of 3.00 s.





magnitude:	0.785 m
direction:	21.2° S of E

Use Newton's Second Law to determine $\vec{a}$, then eq'ns for constant acceleration.

$\Sigma F_x = ma_x$

$F_{water} + F_{current}\cos\theta = ma_x$

$a_x = \dfrac{0.100\text{N} + 0.200\text{N}\cos 52.0°}{2.50\text{ kg}}$

$a_x = 0.08925\text{ m/s}^2$

$\Delta x = v_{ix}\Delta t + \frac{1}{2}a_x(\Delta t)^2$

$\Delta x = (0.110\text{ m/s})(3.00\text{s}) + \frac{1}{2}(0.08925\text{ m/s}^2)(3.00\text{s})^2$

$\Delta x = 0.7316\text{ m}$

$\Sigma F_y = ma_y$

$-F_{current}\sin\theta = ma_y$

$a_y = \dfrac{-0.200\text{N}\sin 52.0°}{2.50\text{ kg}} = -0.06304\text{ m/s}^2$

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

$\Delta y = \frac{1}{2}a_y(\Delta t)^2 = \frac{1}{2}(-0.06304\text{ m/s}^2)(3.00\text{s})^2$

$\Delta y = -0.2837\text{ m}$

$|\Delta\vec{r}| = \sqrt{(\Delta x)^2 + (\Delta y)^2} = 0.785\text{m}$

$\theta_r = \text{invtan}\left(\left|\dfrac{\Delta y}{\Delta x}\right|\right) = 21.2°$

(b) Calculate the instantaneous velocity (magnitude and direction) of the duck at t = 3.00 s.

magnitude:	0.423 m/s
direction:	26.5° S of E

$\Delta v_x = a_x\Delta t$

$v_{fx} - v_{ix} = a_x\Delta t$

$v_{fx} = v_{ix} + a_x\Delta t$

$v_{fx} = 0.110\text{m/s} + (0.0895\text{ m/s}^2)(3.00\text{s})$

$v_{fx} = 0.3785\text{ m/s}$

$\Delta v_y = a_y\Delta t$

$v_{fy} = v_{iy} + a_y\Delta t$

$v_{fy} = (-0.06304\text{ m/s}^2)(3.00\text{s})$

$v_{fy} = -0.1891\text{ m/s}$

$v_f = (v_{fx}^2 + v_{fy}^2)^{1/2} = 0.423\text{ m/s}$

$\theta_v = \text{invtan}\left(\dfrac{|v_{fy}|}{|v_{fx}|}\right) = 26.5°$

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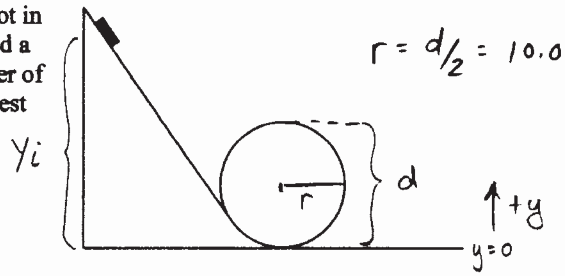
B3. In a stunt for a James Bond movie being shot in winter, a sled of mass 453 kg is to go around a circular vertical loop-the-loop. The diameter of the loop is 20.0 m and the sled starts from rest 40.0 m above the lowest point of the loop. Ignore air resistance and friction.



$r = d/2 = 10.0\,\text{m}$

(a) Calculate the speed of the sled when it is at the top of the loop.

$\boxed{19.8\ \text{m/s}}$

$W_{nc} = 0$ (frictionless)

$K_i + U_i = K_f + U_f$

$\frac{1}{2}mv_i^2 + mgy_i = \frac{1}{2}mv_f^2 + mgy_f$

$0 + \cancel{m}gy_i = \frac{1}{2}\cancel{m}v_f^2 + \cancel{m}gy_f$

$v_f = \sqrt{2g(y_i - y_f)}$

$v_f = \left[2(9.80\,\text{m/s}^2)(40.0\,\text{m} - 20.0\,\text{m})\right]^{1/2}$

$v_f = 19.8\,\text{m/s}$

(b) Calculate the force exerted on the sled by the track at the top of the loop.

$\boxed{1.33 \times 10^4\,\text{N}}$

Circular motion:

$\sum F_r = ma_r$

$N + W = \frac{mv^2}{r}$

$N = \frac{mv^2}{r} - W = \frac{mv^2}{r} - mg = m\left(\frac{v^2}{r} - g\right)$

$N = 453\,\text{kg}\left(\frac{(19.8\,\text{m/s})^2}{10.0\,\text{m}} - 9.80\,\text{m/s}^2\right)$

$N = 1.33 \times 10^4\,\text{N}$

(c) Calculate the minimum height above the bottom of the loop from which the sled can start from rest so that it does not lose contact with the track at the top of the loop.

$\boxed{25.0\,\text{m}}$

The sled loses contact when $N = 0$

From (b), this happens when $m\left(\frac{v^2}{r} - g\right) = 0$

$\therefore v_{min}$ at top is $\sqrt{rg}$

Use Cons. of Mechanical Energy to obtain corresponding $y_{i_{min}}$

$K_i + U_i = K_f + U_f$

$0 + \cancel{m}gy_{i_{min}} = \frac{1}{2}\cancel{m}v_{min}^2 + \cancel{m}gd$

$y_{i_{min}} = \frac{1}{2}\frac{v_{min}^2}{g} + d = \frac{1}{2}\frac{(rg)}{g} + d = \frac{r}{2} + d$

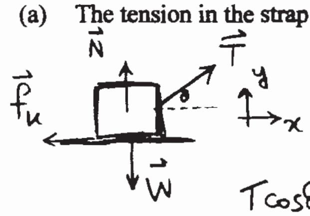
$y_{i_{min}} = \frac{10.0\,\text{m}}{2} + 20.0\,\text{m}$

$y_{i_{min}} = 25.0\,\text{m}$

END OF EXAMINATION

B1. A suitcase is being dragged across the horizontal floor by pulling on its strap. The suitcase has a mass of 22.5 kg and the strap can be approximated as an ideal rope. The strap is at an angle of 36.5° above the horizontal. The coefficient of kinetic friction between the suitcase and the floor is 0.267 and the coefficient of static friction between the suitcase and the floor is 0.342. *Remember to include a free body diagram and choice of coordinates for each of the following parts.*

(a) The tension in the strap is 128 N. Calculate the acceleration of the suitcase.



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

$\boxed{2.86\ m/s^2}$

$\sum F_x = ma \quad ; \quad \sum F_y = 0$

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

$N = W - T\sin\theta$

$N = mg - T\sin\theta$

$T\cos\theta - f_k = ma$

$T\cos\theta - \mu_k N = ma$

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

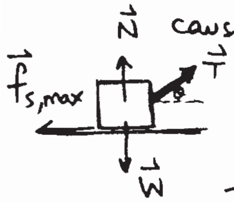
$$a = \frac{T\cos\theta - \mu_k(mg - T\sin\theta)}{m} = \frac{128\,N\cos 36.5° - 0.267\left((22.5\,kg)(9.80\,m/s^2) - 128\,N\sin 36.5°\right)}{22.5\,kg}$$

$a = 2.86\,m/s^2$

(b) The person dragging the suitcase stops, and the suitcase comes to rest. Calculate the minimum tension in the strap required to start the suitcase moving again. The strap is at an angle of 36.5° above the horizontal.

To calculate minimum force (force to just cause suitcase to move) $f_s = f_{s,max}$ and $\sum \vec{F} = 0$

$\boxed{74.9\ N}$



$\sum F_x = 0$

$T\cos\theta - f_{s,max} = 0$

$T\cos\theta - \mu_s N = 0$

$\sum F_y = 0$

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

$N = W - T\sin\theta = mg - T\sin\theta$

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

$T\cos\theta - \mu_s mg + \mu_s T\sin\theta = 0$

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

$$T = \frac{\mu_s mg}{(\cos\theta + \mu_s\sin\theta)}$$

$$T = \frac{(0.342)(22.5\,kg)(9.80\,m/s^2)}{(\cos 36.5° + 0.342\sin 36.5°)}$$

$T = 74.9\,N$

B2. The performance figures for a sports car are quoted as 0 to 100 km/h in 6.00 seconds. You may assume that the final speed is known to 3 significant figures. The mass of the sports car is 1.45×10^3 kg.

(a) Assuming that the acceleration is constant throughout this time interval, calculate the magnitude of the acceleration of the car in m/s^2.

GIVEN: $v_i = 0$ $\quad v_f = 100 \frac{km}{h} \times \frac{1h}{3600s} \times \frac{1000m}{km} = 27.78\,m/s$

$\boxed{4.63\,m/s^2}$

$\Delta t = 6.00\,s$

$\Delta v = a\Delta t$

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{27.78\,m/s}{6.00\,s} = 4.63\,m/s^2$$

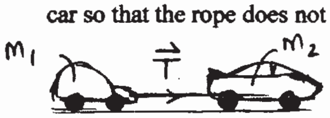
(b) Calculate the magnitude of the net force acting on the car.

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

$\boxed{6.71 \times 10^3 N}$

$$\Sigma F = ma = (1.45 \times 10^3 kg)(4.63\,m/s^2) = 6.71 \times 10^3 N$$

(c) A rope is now attached from the sports car to a Smart car of mass 476 kg. The rope is taut when the two cars are stationary. The rope will break if the tension is greater than 2.00×10^3 N. Neglecting friction, calculate the maximum possible acceleration of the sports car so that the rope does not break.



The sports car and the Smart car will have the same acceleration if the rope doesn't break.

$\boxed{4.20\,m/s^2}$

For Smart car:

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

$T = ma_{max}$

$$a_{max} = \frac{T}{m} = \frac{2.00 \times 10^3 N}{476\,kg} = 4.20\,m/s^2$$

(d) Should the driver of the sports car be concerned that the rope might break? Explain your reasoning.

The sports car is providing the force to accelerate both the sports car and the Smart car. Using the force calculated in (b), the maximum acceleration of the sports car and Smart car combination is $a = \frac{F}{m_1 + m_2} = 3.48\,m/s^2$. Since this is less than the acceleration calculated in (c), the driver does not need to be concerned.

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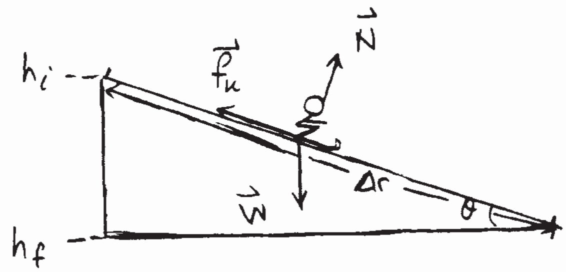
Stu. No.: ____________________

B3. A 75.0 kg skier starts from rest and slides down a 41.5 m long slope, which is inclined at 25.0° to the horizontal. The slope is not frictionless, and the final velocity of the skier is 12.5 m/s. You may neglect air resistance.

(a) Draw a free body diagram of the forces on the skier.



(b) Calculate the work done on the skier by gravity as she skis from the top to the bottom of the slope.

$\boxed{1.29 \times 10^4 \text{ J}}$

$$\Delta U_{grav} = -W_{grav}$$

$$W_{grav} = -\Delta U_{grav}$$

$$W_{grav} = -(mgh_f - mgh_i) = mgh_i - mgh_f$$

$$W_{grav} = mg(\Delta r \sin\theta) = (75.0\text{ kg})(9.80\text{ m/s}^2)(41.5\text{ m})(\sin 25.0°)$$

$$W_{grav} = 1.29 \times 10^4 \text{ J}$$

(c) Calculate the work done on the skier by friction as she skis from the top to the bottom of the slope.

$\boxed{-7.04 \times 10^3 \text{ J}}$

$$W_{tot} = \Delta K$$

$$W_{nc} + W_{cons} = K_f - K_i$$

$$W_{nc} = K_f - K_i - W_{cons} \quad \text{and} \quad W_{cons} = W_{grav}$$

$$W_{nc} = \tfrac{1}{2}mv_f^2 - 0 - W_{grav}$$

$$W_{nc} = \tfrac{1}{2}(75.0\text{ kg})(12.5\text{ m/s})^2 - 1.29 \times 10^4 \text{ J}$$

$$W_{nc} = -7.04 \times 10^3 \text{ J}$$

(d) Calculate the magnitude of the friction force acting on the skier, assuming it is constant.

$\boxed{170 \text{ N}}$

$$W = F \Delta r \cos\theta$$

$$W_{nc} = f_k \Delta r \cos\theta$$

$$f_k = \frac{W_{nc}}{\Delta r \cos\theta} = \frac{-7.04 \times 10^3 \text{ J}}{41.5\text{ m} \cos 180°} = 170 \text{ N}$$

END OF EXAMINATION