UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 115.3
MIDTERM TEST

October 25, 2012 Time: 90 minutes

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

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	$\frac{1}{T}$
l	L
g	$\frac{L}{T^2}$

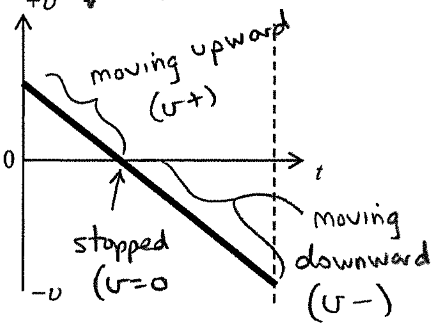
$\frac{L/T^2}{L} = \frac{1}{T^2}$ ✗ $\sqrt{\frac{L/T^2}{L}} = \sqrt{\frac{1}{T^2}} = \frac{1}{T}$ ✓ $\sqrt{\frac{L}{T^2} \cdot L} = L/T$ ✗

(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) $f = 2\pi\sqrt{gl}$

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

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: $a_c = 4a_T$

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

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

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

$v_{f_c} = 2V$

continued on page 3...

B

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.)

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

The magnitude of the resultant ranges from 160 to 240

opposite | same direction

E

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.

(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.

A

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) 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.

$+\uparrow$ $\vec{n}$ $\vec{mg}$

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

$n - mg = ma$

$n = m(a+g)$

To produce an upward acceleration, $n > mg$

E

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?

$+\rightarrow$ $\vec{F}$ $\vec{f_s}$

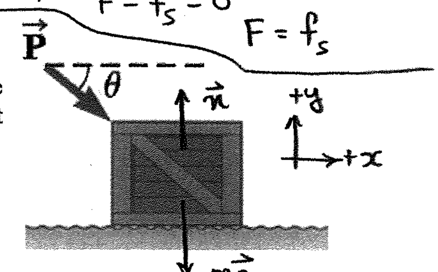
(A) $\mu_s mg$ (B) $\mu_k mg$ (C) $\mu_s F$ (D) $\mu_k F$ (E) F

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

$F = f_s$

E

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?



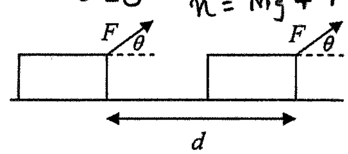
(A) $n = mg$ (B) $n = mg - P\cos\theta$
(C) $n = mg + P\cos\theta$ (D) $n = mg - P\sin\theta$
(E) $n = mg + P\sin\theta$

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

$n = mg + P\sin\theta$

E

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?



	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

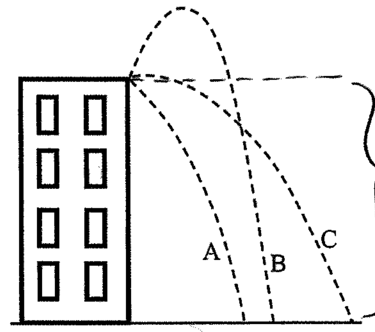
E

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.



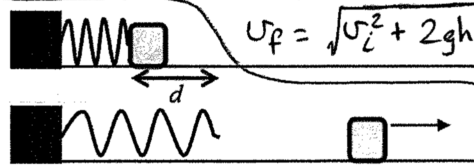
(A) Water balloon A hits with the highest speed.
(B) Water balloon B hits with the highest speed.
(C) Water balloon C hits with the highest speed.
(D) All three water balloons hit the ground with the same speed.
(E) We cannot answer this question without knowing the masses of the water balloons.

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?



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

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

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

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

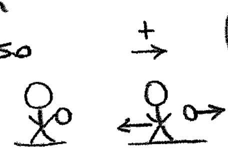
B

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

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



$0 = p_{man} + mV$

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

Situation 1

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

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

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

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.

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

$2(\frac{1}{2}\cancel{k}d_1^2) = \frac{1}{2}\cancel{k}d_2^2$

$2d_1^2 = d_2^2$

continued on page 5...

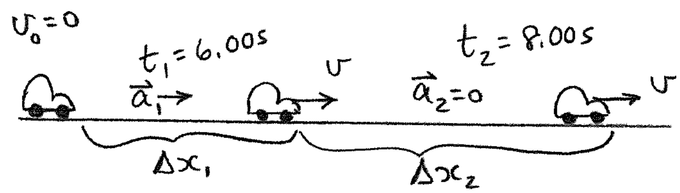
$d_2 = \sqrt{2}\cdot d_1 = \sqrt{2}\cdot d$

Stu. No.: ____________________

B1. A car starts from rest and moves along a straight road. It has a constant acceleration of $3.20\ \mathrm{m/s^2}$ for a time of 6.00 s, reaching a speed υ. Then it stops accelerating and moves with constant speed υ.

(a) Calculate the total distance covered by the car at the end of 14.00 s after it started from rest. (*6 marks*)

$\boxed{211\ \mathrm{m}}$



Need to deal with the two accelerations separately.

$$\Delta x_{tot} = \Delta x_1 + \Delta x_2$$

$$\Delta x_{tot} = \left(\upsilon_0 t_1 + \tfrac{1}{2} a_1 t_1^2\right) + \left(\upsilon t_2 + \tfrac{1}{2} a_2 t_2^2\right)$$

$$\Delta x_{tot} = \tfrac{1}{2} a_1 t_1^2 + \upsilon t_2 \quad \text{and} \quad \upsilon = \upsilon_0 + a_1 t_1 = a_1 t_1$$

$$\Delta x_{tot} = \tfrac{1}{2} a_1 t_1^2 + (a_1 t_1) t_2$$

$$\Delta x_{tot} = \tfrac{1}{2}(3.20\ \mathrm{m/s^2})(6.00\ \mathrm{s})^2 + (3.20\ \mathrm{m/s^2})(6.00\ \mathrm{s})(8.00\ \mathrm{s})$$

$$\Delta x_{tot} = 211\ \mathrm{m}$$

(b) Calculate the average velocity of the car during this 14.00 s time period. Express your answer in km/h. If you did not obtain an answer for (a), use a value of 225 m. (*4 marks*)

$\boxed{54.3\ \mathrm{km/h}}$

$$\bar{\upsilon} = \frac{\Delta x}{\Delta t} = \frac{211\ \mathrm{m}}{14.0\ \mathrm{s}} = 15.1\ \mathrm{m/s}$$

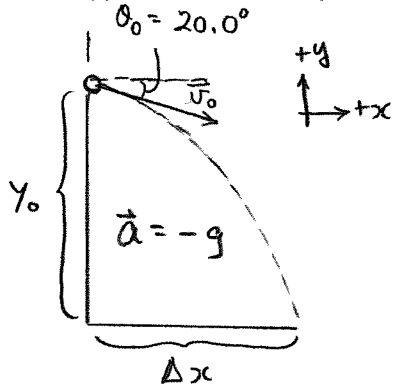
$$15.1\ \frac{\mathrm{m}}{\mathrm{s}} \times \frac{3600\ \mathrm{s}}{\mathrm{h}} \times \frac{1\ \mathrm{km}}{1000\ \mathrm{m}} = 54.3\ \mathrm{km/h}$$

Alt. value: 57.9 km/h

continued on page 6...

B2. From the window of a building, a ball is tossed from a height y_0 above the ground with an initial speed of 8.00 m/s at an angle of 20.0 degrees below the horizontal. It strikes the ground 3.00 s later. (You may ignore air resistance in this problem.)

(a) How far horizontally from the base of the building does the ball strike the ground? (*3 marks*)



x	y
$\Delta x = ?$	$\Delta y = -y_0$
$v_{0x} = v_0 \cos\theta_0$	$v_{0y} = -v_0 \sin\theta_0$
$a_x = 0$	$a_y = -g$
$v_x = v_{0x}$	$v_y = ?$

$t = 3.00\,s$

$\boxed{22.6\,m}$

$$\Delta x = v_{0x} t = v_0 \cos\theta_0 \cdot t$$

$$\Delta x = (8.00\,m/s)(\cos 20.0°)(3.00\,s) = 22.6\,m$$

(b) Find the height from which the ball was thrown. (*3 marks*)

$\boxed{52.3\,m}$

$$\Delta y = v_{0y} t + \tfrac{1}{2} a_y t^2$$

$$\Delta y = -v_0 \sin\theta_0 \cdot t + \tfrac{1}{2}(-g)t^2$$

$$\Delta y = -(8.00\,m/s)(\sin 20.0°)(3.00\,s) - \tfrac{1}{2}(9.80\,m/s^2)(3.00\,s)^2$$

$$\Delta y = -52.3\,m$$

$\therefore$ height = 52.3 m

(c) How long does it take the ball to reach a point 10.0 m below the level of launching? (*4 marks*)

Now $\Delta y = -10.0\,m$

$\boxed{1.18\,s}$

Method 1

$$\Delta y = v_{0y} t + \tfrac{1}{2} a_y t^2$$

$$\Delta y = -v_0 \sin\theta_0 \cdot t + \tfrac{1}{2}(-g)t^2$$

$$\Delta y = -(8.00\,m/s)(\sin 20.0°) \cdot t - \tfrac{1}{2}(9.80\,m/s^2)t^2$$

$$\Delta y = -2.74\,m/s \cdot t - 4.9\,m/s^2 \cdot t^2$$

$$4.9\,m/s^2 \cdot t^2 + 2.74\,m/s \cdot t - 10.0\,m = 0$$

$$t = \frac{-2.74\,m/s \pm \sqrt{(2.74\,m/s)^2 - 4(4.9\,m/s^2)(-10.0\,m)}}{2(4.9\,m/s^2)}$$

$t = 1.18\,s$; $-1.74\,s$

Method 2 Determine v_y from $v_y^2 = v_{0y}^2 + 2a_y \Delta y$

$$v_y^2 = (-v_0 \sin\theta_0)^2 + 2(-g)(\Delta y)$$

$$v_y^2 = [(-8.00\,m/s)(\sin 20.0°)]^2 - 2(9.80\,m/s^2)(-10.0\,m)$$

$$v_y^2 = 203.5\,m^2/s^2$$

$$v_y = -14.26\,m/s$$

$$v_y = v_{0y} + a_y t$$

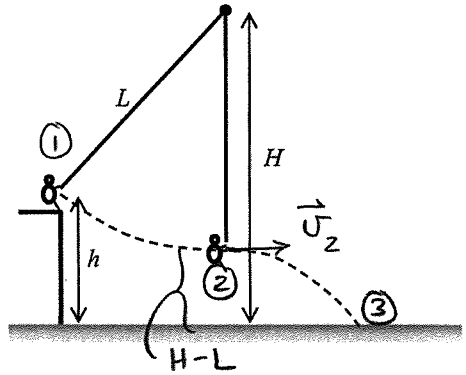
$$t = \frac{v_y - v_{0y}}{a_y}$$

continued on page 7...

$$t = \frac{-14.26\,m/s - (-2.736\,m/s)}{-9.80\,m/s^2}$$

$t = 1.18\,s$

B3. A girl, with mass $m = 60.0$ kg, stands on the bank of a river at a height $h = 2.00$ m above the surface of the water. She holds on to a rope of length $L = 3.00$ m which is attached to an overhanging tree at a point that is a height $H = 4.10$ m above the surface of the water. The rope remains taught as the girl starts from rest from the top of the bank and swings on the rope over the surface of the water as shown. The mass of the rope is negligible and air resistance can be ignored in the motion of the girl.



(a) Calculate the speed of the girl when she reaches the point where the rope is vertical. (*5 marks*)

Air resistance and no non-conservative forces are doing work on the girl.
∴ Mechanical energy is conserved.

$\boxed{4.20\ m/s}$

$$E_1 = E_2$$

$$KE_1 + PE_{g_1} = KE_2 + PE_{g_2} \Rightarrow \cancel{m}gh = \frac{1}{2}\cancel{m}v_2^2 + \cancel{m}g(H-L)$$

$$v_2^2 = 2g(h+L-H) \Rightarrow v_2 = \sqrt{2g(h+L-H)}$$

$$v_2 = \sqrt{2(9.80\,m/s^2)(2.00m + 3.00m - 4.10m)}$$

$$v_2 = 4.20\,m/s$$

(b) At the point where the rope is vertical the girl lets go of the rope. Calculate the speed of the girl just as she hits the water. (*5 marks*)

Mech. energy is still conserved.

$\boxed{6.26\ m/s}$

$$E_1 = E_3$$

$$\cancel{m}gh = \frac{1}{2}\cancel{m}v_3^2$$

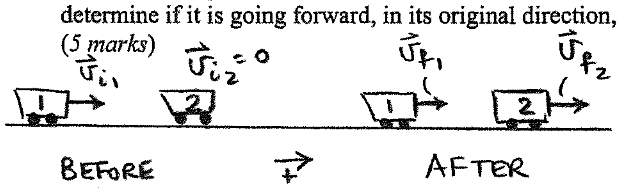
$$v_3 = \sqrt{2gh} = \sqrt{2(9.80\,m/s^2)(2.00\,m)}$$

$$v_3 = 6.26\,m/s$$

continued on page 8...

B4. A toy train car, with mass $m_1 = 0.500$ kg, is moving with speed 0.650 m/s along a straight track toward a stationary train car with mass $m_2 = 0.250$ kg. When the train cars collide they do not stick together. After the collision we find that the second train car, with mass m_2, is moving forward with a speed of 0.826 m/s.

(a) Calculate the speed that the first train car, with mass m_1, is moving after the collision. Also determine if it is going forward, in its original direction, or backward after the collision. (*5 marks*)



speed: $\boxed{0.237 \text{ m/s}}$

Circle your choice:

Forward Backward

Apply Cons. of Momentum to the collision

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

$$m_1\vec{v}_{i_1} + m_2\vec{v}_{i_2} = m_1\vec{v}_{f_1} + m_2\vec{v}_{f_2}$$

with $\vec{v}_{i_2} = 0$

$$\vec{v}_{f_1} = \vec{v}_{i_1} - \frac{m_2}{m_1}\vec{v}_{f_2} = (+0.650\text{ m/s}) - \left(\frac{0.250\text{ kg}}{0.500\text{ kg}}\right)(+0.826\text{ m/s})$$

$$\vec{v}_{f_1} = +0.237\text{ m/s}$$

forward

(b) Calculate the kinetic energy of the system before and after the collision and determine if it is an elastic collision or an inelastic collision. If you did not obtain an answer for (a), use a value of 0.250 m/s. (*5 marks*)

$\boxed{\text{inelastic}}$

$$KE_i = \tfrac{1}{2}m_1v_{i_1}^2 = \tfrac{1}{2}(0.500\text{ kg})(0.650\text{ m/s})^2$$

$$KE_i = 0.106\text{ J}$$

$$KE_f = \tfrac{1}{2}m_1v_{f_1}^2 + \tfrac{1}{2}m_2v_{f_2}^2$$

$$KE_f = \tfrac{1}{2}(0.500\text{ kg})(0.237\text{ m/s})^2 + \tfrac{1}{2}(0.250\text{ kg})(0.826\text{ m/s})^2$$

$$KE_f = 0.0993\text{ J}$$

$KE_f < KE_i \therefore$ not elastic

Alt. value: $KE_f = 0.101\text{ J} < KE_i \quad \therefore$ inelastic

END OF EXAMINATION