AP Physics

Name: ______________________________

Period: ________ Date: __________________

Points: __53____ Score: ______ IB Curve: ______

DEVIL PHYSICS

BADDEST CLASS ON CAMPUS

AP EXAM		CHAPTER TEST	
50 Multiple Choice • 45 Single Response • 5 Multi-Response	90 min, 1 point each	25 Multiple Choice • 22 Single Response • 3 Multi-Response	45 min
Free Response • 3 Short Free Response • 2 Long Free Response	90 min • 13 min ea, 7 pts ea • 25 min ea, 12 pts ea	Free Response • 2 Short Free Response • 1 Long Free Response	45 min • 12 min ea, 7 pts ea • 20 min ea, 12 pts ea

CHAPTER 7 TEST REVIEW -- MARKSCHEME

MULTIPLE CHOICE

1. A rubber ball and a lump of putty have equal mass. They are thrown with equal speed against a wall. The ball bounces back with nearly the same speed with which it hit. The putty sticks to the wall. Which object experiences the greater momentum change?
   a. The ball
   b. The putty
   c. The wall
   d. All experience the same momentum change
   e. Cannot be determined from the information given

   Remember that the rebound velocity is in the opposite direction so it is negative
   $$\Delta p = \left(-mv_f - mv_i\right)$$

2. If you pitch a baseball with twice the kinetic energy you gave it in the previous pitch, the magnitude of its momentum is
   a. The same
   b. 1.41 times as much
   c. 2 times as much
   d. 4 times as much
   e. Cannot be determined without knowing the mass of the baseball

   Since mass doesn't change, only the velocity changes
   $$KE \rightarrow 2KE$$
   $$1/2\, mv^2 \rightarrow 1/2\, m\left(\sqrt{2}v\right)^2 \quad \text{so,}$$
   $$mv \rightarrow m\sqrt{2}v$$

3. Two equal mass balls (one red and the other blue) are dropped from the same height, and rebound off the floor. The red ball rebounds to a higher position. Which ball is subjected to the greater magnitude of impulse during the collision with the floor?
   a. It's impossible to tell since the time intervals and forces are unknown
   b. Both balls were subjected to the same magnitude impulse
   c. The blue ball
   d. The red ball
   e. The floor

   If the red ball rebounded higher, more of its kinetic energy was conserved, which means higher velocity which means more momentum

4. A 100 kg football linebacker moving at 2.0 m/s tackles head-on an 80 kg halfback running 3.0 m/s. Neglecting the effects due to digging in of cleats

   a. The linebacker will drive the halfback backward
   b. The halfback will drive the linebacker backward
   c. Neither player will drive the other backward
   d. They will both move backward the same amount
   e. Cannot be determined without knowing the teams they play for

$$mv_{\text{linebacker}} = 200$$
$$mv_{\text{halfback}} = 240$$

Since the halfback has more momentum, the linebacker will be driven backward

5. A golf ball traveling 3.0 m/s to the right collides in a head-on collision with a stationary bowling ball in a friction-free environment. If the collision is almost perfectly elastic, the speed of the golf ball immediately after the collision is

   a. Slightly less than 3.0 m/s
   b. Slightly greater than 3.0 m/s
   c. Equal to 3.0 m/s
   d. Much less than 3.0 m/s
   e. Cannot be determined without knowing the mass of the two balls

In an elastic collision, kinetic energy is conserved, BUT the golf ball will transfer a *slight* amount of its momentum to the bowling ball so its rebound velocity will be slightly less.

6. A 0.060 kg tennis ball, initially moving at a speed of 12 m/s, is struck by a racket causing it to rebound in the opposite direction at a speed of 18 m/s. What is the change in momentum of the ball?

   a. 0.36 kg·m/s
   b. 0.72 kg·m/s
   c. 0.89 kg·m/s
   d. 1.1 kg·m/s
   e. 1.8 kg·m/s

Remember that the rebound velocity is in the opposite direction so it is negative

$$\Delta p = -mv_f - mv_i$$
$$\Delta p = -(0.060)(18) - (0.060)(12)$$
$$\Delta p = -1.8 m/s$$

7. A 70-kg astronaut is space-walking outside the space capsule and is stationary when the tether line breaks. As a means of returning to the capsule he throws his 2.0 kg space hammer at a speed of 14 m/s away from the capsule. At what speed does the astronaut move toward the capsule?

   a. 0.40 m/s
   b. 1.5 m/s
   c. 3.5 m/s
   d. 5.0 m/s
   e. 7.0 m/s

Momentum is conserved

$$m_{astro} v_{astro} = m_{hammer} v_{hammer}$$
$$v_{astro} = \frac{m_{hammer} v_{hammer}}{m_{astro}}$$
$$v_{astro} = 0.4 m/s$$

8. A 1000 kg car traveling at 25 m/s runs into the rear of a stopped car that has a mass of 1500 kg and they stick together. What is the speed of the cars after the collision?

   a. 5.0 m/s
   b. 10 m/s
   c. 15 m/s
   d. 20 m/s
   e. 25 m/s

Toooootally Inelastic Collision – Momentum Conserved

$$m_1 v_1 = 0 = (m_1 + m_2) v_3$$
$$\frac{m_1 v_1}{(m_1 + m_2)} = \frac{(1000)(25)}{(1000 + 1500)} = v_3$$
$$v_3 = 10 m/s$$

9. A 0.10 kg ball is dropped onto a table top. The speeds of the ball right before and right after hitting the table top are 5.0 m/s and 4.0 m/s, respectively. If the collision between the ball and the table top lasts 0.15 s, what is the magnitude of the average force exerted on the ball by the table top?

   a. 0.67 N
   b. 1.3 N
   c. 3.0 N
   d. 3.5 N
   e. 6.0 N

Impulse

$$I = F(\Delta t) = \Delta mv$$

$$F = \frac{-mv_f - mv_i}{(\Delta t)} = \frac{-(0.10)(4.0) - (0.10)(5.0)}{(0.15)} = 6.0N \cdot s$$

10. A fire hose is turned on the door of a burning building in order to knock the door down. This requires a force of 1000 N. If the hose delivers 40 kg per second, what is the minimum velocity of the stream of the stream needed, assuming the water doesn't bounce back?

   a. 0.63 m/s
   b. 15 m/s
   c. 20 m/s
   d. 25 m/s
   e. 30 m/s

Impulse

$$I = F(\Delta t) = \Delta mv$$

$$F = \frac{0 - mv_i}{(\Delta t)} = \frac{-m}{\Delta t} v_i = \frac{40kg}{s} v_i$$

$$\frac{F}{40} = \frac{(1000)}{40} = v_i = 25m/s$$

11. (__/1) Which one of the following statements concerning momentum is true?

   a. Momentum is a force – it's not
   b. Momentum is a scalar quantity – no, it's a vector
   c. The SI unit of momentum is the kilogram-meter squared per second or kg·m^2/s – no, it's kg·m/s
   d. The momentum of an object is always positive – no, sometimes it is negative
   e. Momentum has the same units as impulse

12. (__/1) A 0.1 kg steel ball is dropped straight down onto a hard, horizontal floor and bounces straight up. Its speed immediately before and immediately after impact with the floor is 10.0 m/s. What is the magnitude of the impulse delivered to the floor by the steel ball?

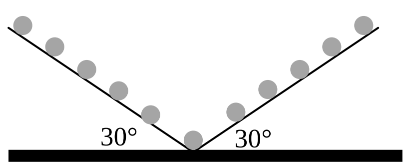
   a. 0 N·s
   b. 1 N·s
   c. 2 N·s
   d. 10 N·s
   e. 100 N·s

Impulse

$$I = \Delta mv$$

$$I = -mv_f - mv_i = -(0.1)(10) - (0.1)(10)$$

$$I = 2N \cdot s$$



13. (__/1) A beam of *n* gas molecules is incident upon a barrier at 30° relative to the horizontal as shown. Each molecule has mass *m* and speed *v*, and the entire beam is reflected elastically, also at 30°. What is the magnitude of the total change of momentum of the particle beam during this event?

   a. 2*nmv*
   b. 1.73*nmv*
   c. 0.866*nmv*
   d. 0.500*nmv*
   e. *Nmv*

The x-component of the momentum (mv cos 30°) is the same for both so they cancel out. The y-components (mv sin 30°) are in opposite directions so they are additive. Also, you must multiply the momentum of each molecule by the number of molecules (n).

$I = \Delta mv$ $I = -nmv \sin 30 - nmv_i \sin 30$

$I = -nmv_f - nmv_i$ $I = (2 \sin 30)nmv = nmv$

14. (__/1) Which of the following five objects requires the greatest change in momentum to stop it?

Object	Mass (kg)	Speed (m/s)	Momentum
(a) Electron	10^{-30}	10^{8}	10^{-22}
(b) Oil Tanker	10^{8}	10^{-1}	10^{7}
(c) Raindrop	10^{-4}	10	10^{-3}
(d) Snail	10^{-2}	10^{-4}	10^{-6}
(e) Satellite	10	10^{4}	10^{5}

15. (__/1) A baseball of mass *m* (at rest, T-ball?) is struck by a bat so that it acquires a speed *v*. If *t* represents the duration of the collision between the bat and the ball, which expression determines the magnitude of the average force exerted on the ball?

a. $\frac{1}{2}mv^2$
b. $\frac{mv}{t}$
c. $\frac{1}{2}mv^2t$
d. $\frac{1}{2}\left(\frac{mt^2}{v}\right)$
e. mvt

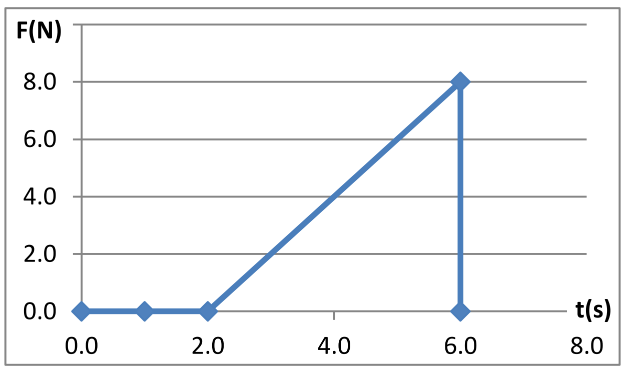
Impulse
$I = F(\Delta t) = \Delta mv$
$F = \frac{mv_f - 0}{(\Delta t)} = \frac{mv}{t}$

16. (__/1) A sled of mass *m* is coasting on a frozen river when, while passing under a bridge, a box of mass *m* falls straight down and lands on the sled. The sled and box continue along the original line of motion. How does the kinetic energy of the sled with the box compare to the original kinetic energy of the sled?

a. It is one-fourth the original kinetic energy of the sled
b. It is one-half the original kinetic energy of the sled
c. It is three-fourths the original kinetic energy of the sled
d. It is the same as the original kinetic energy of the sled
e. It is two times the original kinetic energy of the sled

Momentum is conserved
$m_{sled}v_{sled} = (m_{sled} + m_{box})v_{both}$
$\frac{m_{sled}v_{sled}}{(m_{sled} + m_{box})} = \frac{mv_{sled}}{(m+m)} = \frac{1}{2}v_{sled}$
$KE_{new} = \frac{1}{2}m\left(\frac{1}{2}v_{sled}\right)^2 = \frac{1}{4}KE_{old}$

(__/1) A 2.0 kg object is acted upon by a single force in the positive x-direction as shown. What is the momentum change experienced by the object during the first 6 s?

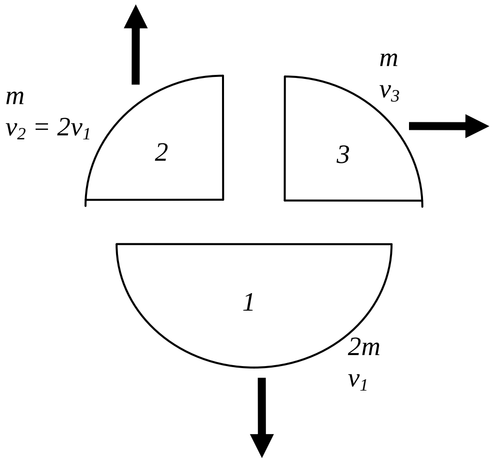


a. 16.0 N·s
b. 30.0 N·s
c. 32.0 N·s
d. 40.0 N·s
e. 48.0 N·s

Impulse
$I = F(\Delta t) = \Delta mv$
Area under an F vs. Δt graph is equal to impulse
$I = F(\Delta t) = \Delta mv = \frac{1}{2}(4)(6) = 16N \cdot s$

17. (__/1) An in-flight projectile in dynamic equilibrium explodes into several fragments. What happens instantaneously to its momentum following this explosion?

a. It has been changed into kinetic energy of the fragments
b. It is less than that immediately before the explosion
c. It is the same as that immediately before the explosion, by the law of conservation of momentum
d. It is more than that immediately before the explosion.
e. It has been changed into radiant energy



Conservation of Momentum
$p_T = m_1\vec{v_1} + m_2\vec{v_2} + m_3\vec{v_3}$
$m_{1+2+3}v_{vert} = m(2v_1) - (2m)v_1 = 0$
$m_{1+2+3}v_{horiz} = mv_3$
$4mv_{horiz} = mv_3$
$v_{horiz} = \frac{mv_3}{4m} = \frac{v_3}{4}$

18. (__/1) A projectile has just exploded into three pieces, with the velocities of each piece as shown. What was the speed of the projectile the instant before it broke up?

a. v_3
b. $\frac{v_3}{3}$
c. $4v_3$
d. $\frac{v_3}{4}$
e. $\frac{v_1+v_2+v_2}{4}$

19. A rifle of mass *M* is initially at rest but is free to recoil. It fires a bullet of mass *m* and velocity +*v* (relative to the ground). After firing, what is the velocity of the rifle (relative to the ground)?

a. $-mv$
b. $\frac{-Mv}{m}$
c. $\frac{-mv}{M}$
d. $-v$
e. $\frac{+mv}{M}$

Conservation of Momentum
$0 = MV + mv$
$-mv = MV$
$\frac{-mv}{M} = V$

For questions **21** and **22**, refer to the following information: A space vehicle of mass *m* has a speed *v*. At some instant, it explodes into two pieces, each of mass ½ *m*. One of the pieces is at rest just after the separation. This event occurs very far from any celestial body.

20. Which of the following statements concerning this situation is true?

    a. The moving piece has speed 2*v*.
    b. The moving piece has speed *v*.
    c. The piece at rest possesses kinetic energy.
    d. The moving piece has speed ½ *v*.
    e. This process does not conserve momentum.

Conservation of Momentum

$$mv = 1/2\, mv_{piece} + 0$$
$$\frac{2mv}{m} = v_{piece}$$
$$2v = v_{piece}$$

21. What is the kinetic energy of the moving piece just after the separation?

    a. 0
    b. ¼ mv^2
    c. ½ mv^2
    d. mv^2
    e. 2 mv^2

Conservation of Momentum

$$mv = 1/2\, mv_{piece} + 0$$
$$\frac{2mv}{m} = v_{piece}$$
$$2v = v_{piece}$$

22. A 50.0 kg boy runs at a speed of 10.0 m/s and jumps onto a cart that is initially at rest. If the speed of the cart with the boy on it is 2.50 m/s, what is the mass of the cart?

    a. 150.0kg
    b. 175.0kg
    c. 210.0kg
    d. 260.0kg
    e. 300.0kg

Momentum is conserved

$$m_{boy}v_{boy} = (m_{boy} + m_{cart})v_{both}$$
$$m_{boy}v_{boy} = m_{boy}v_{both} + m_{cart}v_{both}$$
$$m_{boy}v_{boy} - m_{boy}v_{both} = m_{cart}v_{both}$$
$$\frac{m_{boy}v_{boy} - m_{boy}v_{both}}{v_{both}} = m_{cart}$$
$$m_{cart} = \frac{(50)(10) - (50)(2.5)}{(2.5)} = 150kg$$

23. An object of momentum p and mass m is in motion. At the moment it is moving with speed v, what is its kinetic energy?

    a. $\frac{2p^2}{m^2}$
    b. $\frac{p}{2m}$
    c. $\frac{p^2}{2}$
    d. $\frac{p^2}{2m}$
    e. $\frac{p^2}{2v}$

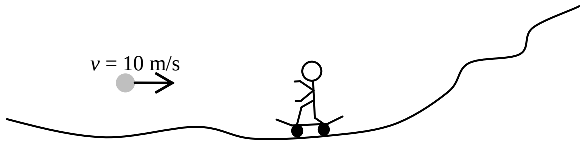
Definition of momentum and kinetic energy

$$p = mv$$
$$\frac{p}{m} = v$$
$$KE = \frac{1}{2}mv^2$$
$$KE = \frac{1}{2}m\left(\frac{p}{m}\right)^2 = \frac{mp^2}{2m^2} = \frac{p^2}{2m}$$

24. Which of the following statements concerning an inelastic collision is true? *(circle all that apply)*

    a. Total mass and momentum are conserved.
    b. Total mass is not conserved, but momentum is conserved. – momentum is always conserved
    c. Neither kinetic energy nor momentum is conserved. – momentum is always conserved
    d. Momentum is conserved, but kinetic energy is not conserved.
    e. The total impulse is equal to the change in mass. – impulse = change in momentum
    f. The total impulse is equal to the change in momentum.

FREE RESPONSE



25. A 26.0 kg boy is standing at rest on a 4.0 kg skateboard at the bottom of a frictionless, but uneven, hill as shown. A 5.0 kg ball comes at him with a horizontal velocity of 10.0 m/s to the right, and he catches the ball and remains on the skateboard.

a. (__/2) Determine the speed of the boy the moment after he catches the ball.

$m_{ball}v_{ball} = (\mathbf{m_{boy}} + \mathbf{m_{sb}} + \mathbf{m_{ball}})\mathbf{v_{all}}$

$\frac{m_{ball}v_{ball}}{(\mathbf{m_{boy}}+\mathbf{m_{sb}}+\mathbf{m_{ball}})} = \mathbf{v_{all}}$

$\frac{(5)(10)}{(26+4+5)} = \mathbf{v_{all}} = \mathbf{1.43\ m/s}$

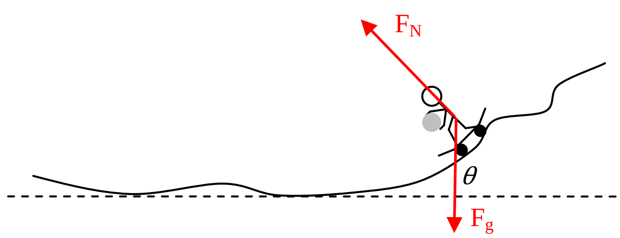
b. (__/3) Determine how high up the hill the boy with the ball on the skateboard coasts until momentarily (no pun intended) coming to rest.

$KE = PE$

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

$\frac{v_{all}^2}{2g} = h = \frac{(1.43)^2}{2(9.81)} = \mathbf{0.104}m$

c. (__/2) Sketch the free-body diagram of the boy as he stops on the hill in the diagram below.



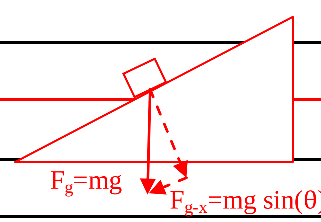
d. (__/2) The boy now begins to accelerate down the hill, which is tilted relative to the horizontal by the angle θ. Derive an expression for the boy's acceleration in terms of g and θ

$\Sigma F = ma$

$F_g = ma$

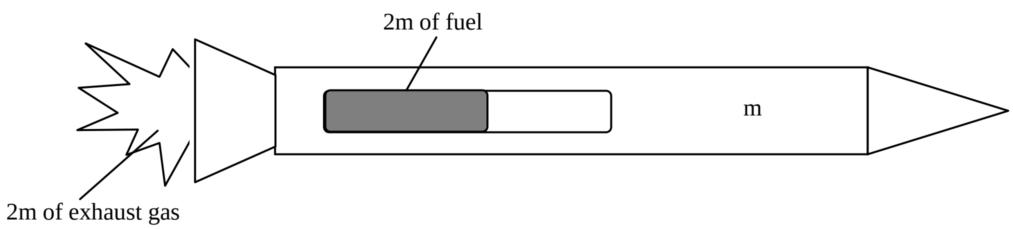
$\cancel{m}g \sin\theta = \cancel{m}a$

$g \sin\theta = a$



e. (__/1) What percentage of Earth's gravitational acceleration is the boy's acceleration if the angle of the hill is 49°?

$\frac{g\sin\theta}{g} = \sin\theta = \sin 49° = 0.75 = 75\%$



26. A rocket of mass *m* initially carries an additional mass of fuel equal to *4m* as shown. The rocket is in deep space, very far from any stars or planets, and therefore has negligible external forces on it and is initially at rest. The rocket engine fires, causing the rocket to consume (at a constant rate) a mass of *2m* of fuel expelled out the nozzle as hot gas moving at speed *v* (relative to the original rest frame). Left behind is *2m* of unburned fuel.

a. (__/1) After the gas is emitted, what is the magnitude of the momentum of the exhaust gas? Express your answer in terms of *m* and *v*.

$\mathbf{p_{gas} = m_{gas}v_{gas} = 2mv}$

b. (__/2) After the gas is emitted, what is the speed of the rocket? Express your answer in terms of *m* and *v*.

$\mathbf{p_{gas} = p_{rocket}}$

$\mathbf{m_{gas}v_{gas} = m_{rocket}v_{rocket}}$

$\mathbf{2mv = 3mv_{rocket}}$

$\mathbf{\frac{2\cancel{m}v}{3\cancel{m}} = v_{rocket}}$

$\mathbf{\frac{2v}{3} = v_{rocket}}$

c. (__/2) If the time during which the gas is expelled is *Δt*, what was the average force *F* on the rocket by the gas during the fuel burn? Express your answer in terms of *m*, *v* and *Δt*.

$\boldsymbol{F_{gas}(\Delta t) = \mathbf{p_{gas}}}$

$\boldsymbol{F_{gas} = \frac{\mathbf{p_{gas}}}{(\Delta t)}}$

$\boldsymbol{F_{gas} = \frac{\mathbf{2mv}}{(\Delta t)}}$

27. A ball of mass 400 g moving toward the east with a speed of 3.70 m/s collides head-on with a 200 g ball sitting at rest. The collision is perfectly elastic.

   a. (__/3) Determine the velocity (magnitude and direction) of the first ball after the collision.

   Define east as positive direction and west as negative direction

   $\mathbf{m_1v_1 + \cancel{m_2v_2} = m_1v_1' + m_2v_2'}$

   $\mathbf{m_1v_1 = m_1v_1' + m_2v_2'}$

   $\mathbf{v_1 - \cancel{v_2} = v_2' - v_1'}$

   $\mathbf{v_1 = v_2' - v_1'}$

   $\mathbf{v_1 + v_1' = v_2'}$

   $\mathbf{3.7 + v_1' = v_2'}$

   $\mathbf{m_1v_1 = m_1v_1' + m_2(3.7 + v_1')}$

   $\mathbf{m_1v_1 = m_1v_1' + 3.7m_2 + m_2v_1'}$

   $\mathbf{m_1v_1 - 3.7m_2 = (m_1 + m_2)v_1'}$

   $\mathbf{\frac{m_1v_1 - 3.7m_2}{(m_1 + m_2)} = v_1'}$

   $\mathbf{\frac{(0.4)(3.7) - (3.7)(0.2)}{(0.4 + 0.2)} = v_1' = 1.233\ m/s}$ **east**

   b. (__/2) Determine the velocity (magnitude and direction) of the second ball after the collision.

   $\mathbf{3.7 + v_1' = v_2'}$ **from a. above**

   $\mathbf{3.7 + 1.233 = v_2' = 4.933\ m/s}$ **east**

   c. (__/2) Show that kinetic energy is conserved in this collision.

   $\boldsymbol{KE_1 = KE_1' + KE_2'}$

   $\boldsymbol{\frac{1}{2}m_1v_1^2 = \frac{1}{2}m_1v_1'^2 + \frac{1}{2}m_2v_2'^2}$

   $\mathbf{\frac{1}{2}(0.4)(3.7)^2 = \frac{1}{2}(0.4)(1.233)^2 + \frac{1}{2}(0.2)(4.933)^2}$

   $\mathbf{2.74J = 0.304 + 2.433}$

   $\mathbf{2.74J = 2.737 = 2.74J}$

28. A 15 g bullet travelling 213 m/s in a vertical direction buries itself in a 2.4 kg block of wood at rest directly above it. As a result, the bullet/block combination moves vertically upward.

   a. (__/2) Determine the velocity of the bullet/block combination immediately after impact.

   Remember to convert the mass of the bullet from grams to kilograms

   $\mathbf{p_{bullet} = p_{bullet+block}}$

   $\mathbf{m_{bullet}v_{bullet} = (m_{bullet} + m_{block})v_{both}}$

   $\mathbf{\frac{m_{bullet}v_{bullet}}{(m_{bullet} + m_{block})} = v_{both}}$

   $\mathbf{\frac{(0.015)(213)}{(0.015 + 2.4)} = v_{both} = 1.32\ m/s}$

b. (__/2) Determine the maximum height reached by the bullet/block combination.

0.089 m Since the bullet and block stick together, it is an inelastic collision. This means you can't use conservation of energy and you must use a kinematic equation

$\cancel{v^2} = v_0{}^2 + 2gy$ $\qquad y = \frac{(1.32)^2}{(-2)(-9.81)} = 0.089m$

$-2gy = v_0{}^2$

$y = \frac{v_0{}^2}{-2g}$

c. (__/3) Prove whether or not mechanical energy is conserved.

No, it is an inelastic collision. Prove it by comparing the kinetic energy of the bullet to either the kinetic energy of the combination or the gain in potential energy of the combination

$KE_{bullet} = KE_{both}$ $\qquad KE_{bullet} = PE_{both}$

$\frac{1}{2}m_{\text{bullet}}v_{\text{bullet}}{}^2 = \frac{1}{2}m_{\text{both}}v_{\text{both}}{}^2$ $\qquad \frac{1}{2}m_{\text{bullet}}v_{\text{bullet}}{}^2 = m_{both}gh$

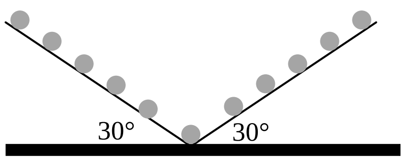
$\frac{1}{2}(0.015)(213)^2 = \frac{1}{2}(2.415)(1.32)^2$ $\qquad \frac{1}{2}(0.015)(213)^2 = (2.415)(9.81)(0.089)$

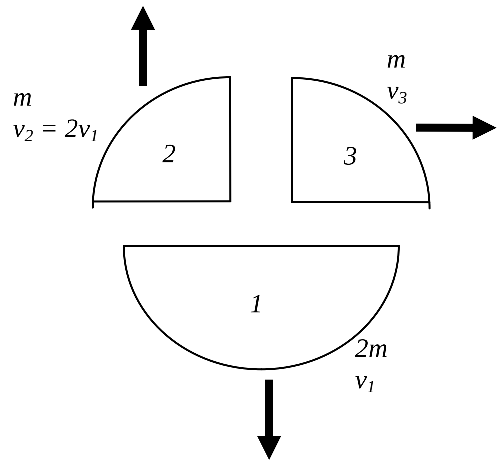
$340.3 \neq 2.104$ $\qquad 340.3 \neq 2.109$

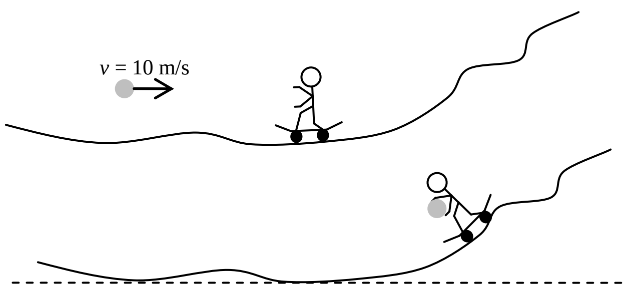
The lost energy was taken up by the work due to friction between the bullet and the wood in stopping the bullet's motion. That work was used to create heat.

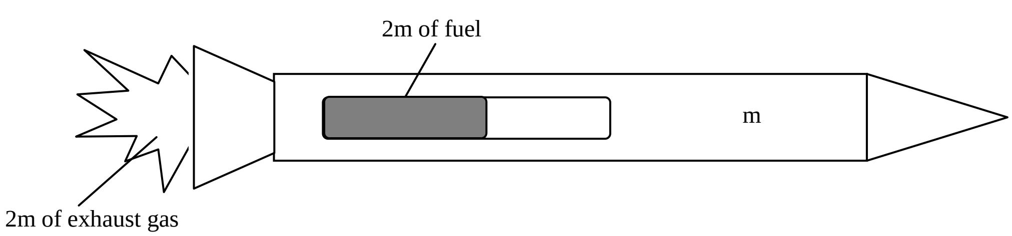
29. .

a. (__/X)









-