AP Physics B Momentum Test H

Notes: This test includes Kinematics, Forces & Energy Concepts. You should include the guessing penalty on this and all future tests.

Guessing Penalty for MC Questions:
Correct = Full credit
Incorrect = −1/4 credit
Blank = 0

<u>45 min version</u>:
12 MC at 1.25 pts each = 15 pts
2 FR at 15 pts each = 30 pts
45 pts total

Students need 62.5% of 45 = **28 pts**
Divide student points by 28 for their grade.

<u>80 min version</u>:
16 MC at 1.25 pts each = 20 pts
4 FR at 15 pts each = 60 pts
80 pts total

Students need 62.5% of 80 pts = **50 pts**
Divide student points by 50 for their grade.

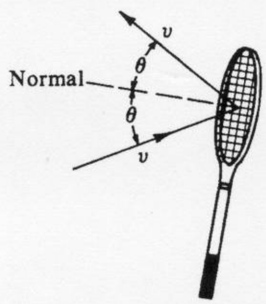
AP Physics B – Momentum 80 min Test version: H **Name**_____Key_____ **Per**___

1) A railroad flatcar of mass 2,000 kilograms rolls to the right at 10 meters per second and collides with a flatcar of mass 3,000 kilograms that is rolling to the left at 5 meters per second. The flatcars couple together. Their speed after the collision is

(A) 1m/s
(B) 2.5m/s
(C) 5 m/s
(D) 7 m/s
(E) 7.5m/s

2) Which of the following quantities is a scalar that is always positive or zero?

(A) Power
(B) Work
(C) Kinetic energy
(D) Linear momentum
(F) Annular momentum

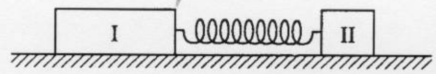


3) A tennis ball of mass m rebounds from a racquet with the same speed v as it had initially, as shown above. The magnitude of the momentum change of the ball is

(A) 0
(B) mv
(C) $2mv$
(D) $2mv \sin\theta$
(E) $2mv \cos\theta$

4) Two bodies of masses 5 and 7 kilograms are initially at rest on a horizontal frictionless surface. A light spring is compressed between the bodies, which are held together by a thin thread. After the spring is released by burning through the thread, the 5-kilogram body has a speed of 1/5 meter per second. The speed of the 7-kilogram body is

(A) 1/12 m/s
(B) 1/7 m/s
(C) $\frac{1}{\sqrt{35}} m/s$
(D) 1/5 m/s
(E) 7/25 m/s



5) Two pucks are attached by a stretched spring and are initially held at rest on a frictionless surface, as shown above. The pucks are then released simultaneously. If puck I has three times the mass of puck II, which of the following quantities is the same for both pucks as the spring pulls the two pucks toward each other?

(A) Speed
(B) Velocity
(C) Acceleration
(D) Kinetic energy
(E) Magnitude of momentum

6) Which of the following is true when an object of mass m moving on a horizontal frictionless surface hits and sticks to an object of mass M > m, which is initially at rest on the surface?

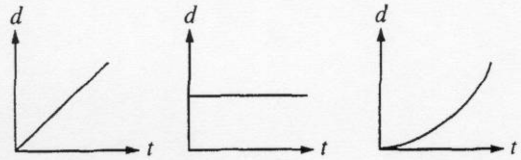
(A) The collision is elastic.
(B) All of the initial kinetic energy of the less-massive object is lost.
(C) The momentum of the objects that are stuck together has a smaller magnitude than the initial momentum of the less-massive object.
(D) The speed of the objects that are stuck together will be less than the initial speed of the less-massive object.
(E) The direction of motion of the objects that are stuck together depends on whether the hit is a head-on collision.

7) Two objects having the same mass travel toward each other on a flat surface, each with a speed of 10 meter per second relative to the surface. The objects collide head-on and are reported to rebound after the collision, each with a speed of 20 meters per second relative to the surface. Which of the following assessments of this report is most accurate?

(A) Momentum was not conserved, therefore the report is false.
(B) If potential energy was released to the objects during the collision, the report could be true.
(C) If the objects had different masses, the report could be true.
(D) If the surface was inclined, the report could be true.
(E) If there was no friction between the objects and the surface, the report could be true.

Questions 8-9)

Three objects can only move along a straight, level path. The graphs below show the position d of each of the objects plotted as a function of time t.



I II III

8) The magnitude of the momentum of the object is increasing in which of the cases?

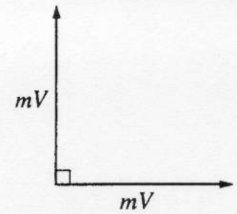
(A) II only
(B) III only
(C) I and II only
(D) I and III only
(E) I, II, and III

9) The sum of the forces on the object is zero in which of the cases?

(A) II only
(B) III only
(C) I and II only
(D) I and III only
(E) I, II, and III

10) Two people of unequal mass are initially standing still on ice with negligible friction. They then simultaneously push each other horizontally. Afterward, which of the following is true?

(A) The kinetic energies of the two people are equal.
(B) The speeds of the two people are equal.
(C) The momenta of the two people are of equal magnitude.
(D) The center of mass of the two-person system moves in the direction of the less massive person.
(E) The less massive person has a smaller initial acceleration than the more massive person.



11) A stationary object explodes, breaking into three pieces of masses m, m, and $3m$. The two pieces of mass m move off at right angles to each other with the same magnitude of momentum mV, as shown in the diagram above. What are the magnitude and direction of the velocity of the piece having mass $3m$?

	Magnitude	Direction
(A)	$\frac{V}{\sqrt{3}}$	↗
(B)	$\frac{V}{\sqrt{3}}$	↙
(C)	$\frac{\sqrt{2}\,V}{3}$	↗
(D)	$\frac{\sqrt{2}\,V}{3}$	↙
(E)	$\sqrt{2}\,V$	↙

12) Which of the following statements is/are always true for completely inelastic collisions?

I. System total mechanical energy is not conserved.

II. System momentum is conserved.

III. The objects stick together.

(A) I
(B) II
(C) I and II
(D) I and III
(E) I, II, and III

13) In which of the following collisions is total mechanical energy NOT conserved?

I. elastic

II. partially inelastic

III. completely inelastic

(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III

14) What braking force is applied to a 2500-kilogram car having a velocity of 30 meters per second if the car is brought to a stop in 15 seconds?

(A) 5000 N
(B) 6000 N
(C) 8000 N
(D) 10,000 N
(E) 12,000 N

15) A 1-kilogram object is moving to the right with a velocity of 6 meters per second. It collides with, and sticks to, a 2-kilogram mass, also moving to the right, with a velocity of 3 meters per second. How much kinetic energy was lost in this interaction?

(A) 1.5 J
(B) 2 J
(C) 3 J
(D) 3.5 J
(E) 0 J

$6 + 6 = 12$

$v = \frac{12}{3} = 4$ m/s

$K_i = 18J + 9J = 27J$

$K_f = 24J$

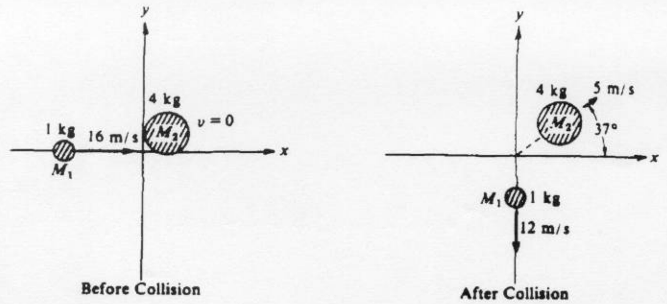
$\Delta K = 27 - 24 = 3J$

16) A ball with a mass of 0.2 kilogram strikes a wall with a velocity of 3 meters per second. It bounces straight back with a velocity of 1 meter per second. What was the magnitude of the change in momentum for this ball?

(A) 0.1 kg · m/s
(B) 0.8 kg · m/s
(C) 0.4 kg · m/s
(D) 0.6 kg · m/s
(E) 0.7 kg · m/s

$\Delta p = m\Delta v = (.2)(-4)$

15pts



View From Above

1984B2 (15 points)

Two objects of masses M_1 = 1 kilogram and M_2 = 4 kilograms are free to slide on a horizontal frictionless surface. The objects collide and the magnitudes and directions of the velocities of the two objects before and after the collision are shown on the diagram above. (sin 37° = 0.6, cos 37° = 0.8, tan 37° = 0.75)

a. Calculate the x and y components (p_x and p_y, respectively) of the momenta of the two objects before and after the collision, and write your results in the proper places in the following table. (8pts)

1pt each

	M_1 = 1 kg		M_2 = 4 kg	
	$p_x\left(\frac{kg\cdot m}{s}\right)$	$p_y\left(\frac{kg\cdot m}{s}\right)$	$p_x\left(\frac{kg\cdot m}{s}\right)$	$p_y\left(\frac{kg\cdot m}{s}\right)$
Before Collision	16	0	0	0
After Collision	0	12	16	-12

b. Show, using the data that you listed in the table, that linear momentum is conserved in this collision. (3pts)

① showing $p_{xi} = p_{xf}$

① showing $p_{yi} = p_{yf}$

① extra point for showing both

c. Calculate the kinetic energy of the two-object system before and after the collision. (3pts)

① $K = \frac{1}{2}mv^2$

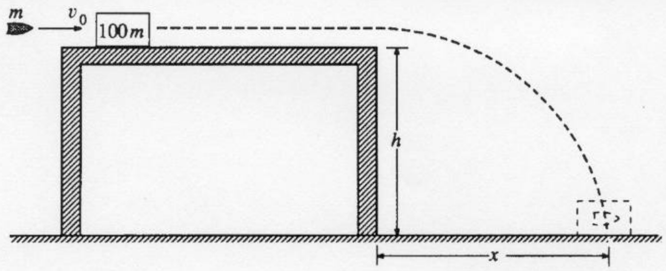
$K_i = \frac{1}{2}(1)(16)^2 = 128\,J$ ①

$K_f = \frac{1}{2}(1)(12)^2 + \frac{1}{2}(4)(5)^2 = 122\,J$ ①

d. Is kinetic energy conserved in the collision? (1pt)

① No

15pts



1990B1 (15 points)

A bullet of mass m is moving horizontally with speed v_o when it hits a block of mass 100m that is at rest on a horizontal frictionless table, as shown above. The surface of the table is a height h above the floor. After the impact the bullet and the block slide off the table and hit the floor a distance x from the edge of the table. Derive expressions for the following quantities in terms of m, h, v_o, and appropriate constants:

3pts a. the speed of the block as it leaves the table

① Conservation of momentum

① $p = mv$

$mv_o = 101\, mv_f$

① $\boxed{v_f = \frac{v_o}{101}}$

4pts b. the change in kinetic energy of the bullet-block system during impact

① $K = \frac{1}{2}mv^2$

$K_i = \frac{1}{2}mv_o^2$

① $K_f = \frac{1}{2}(101m)\left(\frac{v_o}{101}\right)^2$

① $\Delta K = K_f - K_i$

① $\boxed{\Delta K = -\frac{50}{101}mv_o^2}$

4pts c. the distance x

① $x = vt$

① $h = \frac{1}{2}gt^2$

① $t = \sqrt{\frac{2h}{g}}$

① $\boxed{x = \frac{v_o}{101}\sqrt{\frac{2h}{g}}}$

Suppose that the bullet passes through the block instead of remaining in it.

2pts d. State whether the time required for the block to reach the floor from the edge of the table would now be greater, less, or the same. Justify your answer.

① Time is the same

① Reasonable Justification

2pts e. State whether the distance x for the block would now be greater, less, or the same. Justify your answer.

① X is less

① Reasonable Justification

1992B2 (15 points)

A 30-kilogram child moving at 4.0 meters per second jumps onto a 50-kilogram sled that is initially at rest on a long, frictionless, horizontal sheet of ice.

4 pts a. Determine the speed of the child-sled system after the child jumps onto the sled.

(1) $p_1 = p_2$

(1) $p = mv$

(1) Inelastic

(1) $V = 1.5\ m/s$

3 pts b. Determine the kinetic energy of the child-sled system after the child jumps onto the sled.

(1) $K = \frac{1}{2}mv^2$

(1) K_{total} includes both sled & child

(1) $K = 90\ J$

After coasting at constant speed for a short time, the child jumps off the sled in such a way that she is at rest with respect to the ice.

3 pts c. Determine the speed of the sled after the child jumps off it.

(1) Correct statement of Conservation of Momentum

(1) $P_{child\ final} = 0$

(1) $V_{sled} = 2.4\ m/s$

2 pts d. Determine the kinetic energy of the child-sled system when the child is at rest on the ice.

(1) $K = \frac{1}{2}(50)(2.4)^2$ sled only

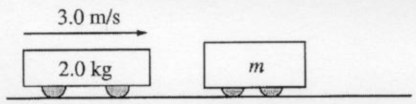
(1) $K = 144\ J$

2 pts e. Compare the kinetic energies that were determined in parts (b) and (d).
If the energy is greater in (d) than it is in (b), where did the increase come from?
If the energy is less in (d) than it is in (b), where did the energy go?

(1) Energy is greater

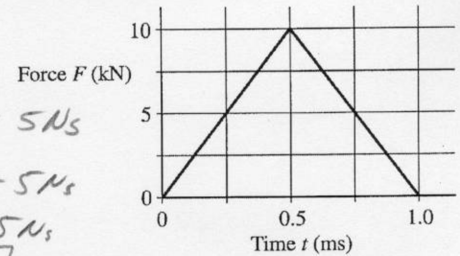
(1) Explanation: Energy input from childs legs or + Work from Child increases K.

1 pt (1) Extra Point for units



2002B1B (15 points)

A 2.0 kg frictionless cart is moving at a constant speed of 3.0 m/s to the right on a horizontal surface, as shown above, when it collides with a second cart of undetermined mass m that is initially at rest. The force F of the collision as a function of time t is shown in the graph below, where $t = 0$ is the instant of initial contact. As a result of the collision, the second cart acquires a speed of 1.6 m/s to the right. Assume that friction is negligible before, during, and after the collision.



4 pts (a) Calculate the magnitude and direction of the velocity of the 2.0 kg cart after the collision.

(1) $J = \Delta p$

(1) Δp = Area under graph

(1) Recognizing that J is negative on 2kg cart

$\Delta p = \frac{1}{2} bh = 5 Ns$

$p_f = p_i - 5 Ns$

$= 6 - 5 Ns$

(1) $= 1 Ns$

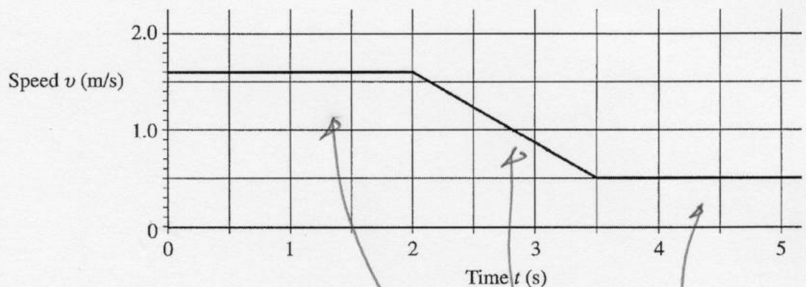
3 pts (b) Calculate the mass m of the second cart.

(1) $p_i = p_f$

(1) $(p_2)_i = (p_2 + p_m)_f$

(1) $m = 3.1 kg$

After the collision, the second cart eventually experiences a ramp, which it traverses with no frictional losses. The graph below shows the speed v of the second cart as a function of time t for the next 5.0 s, where $t = 0$ is now the instant at which the carts separate.



2 pts (c) Calculate the acceleration of the cart at $t = 3.0$ s.

(1) a = slope

(1) $a = -0.73 \, m/s^2$

3 pts (d) Calculate the distance traveled by the second cart during the 5.0 s interval after the collision ($0 \text{ s} < t < 5.0 \text{ s}$).

(1) Using area under graph or equations

(1) Calculating the distance for each segment of graph 3.2m + 1.6m + 0.8m

(1) $d_{total} = 5.5 m$

3 pts (e) State whether the ramp goes up or down and calculate the maximum elevation (above or below the initial height) reached by the second cart on the ramp during the 5.0 s interval after the collision ($0 \text{ s} < t < 5.0 \text{ s}$).

(1) Ramp goes up

(1) Conservation of Energy $mgh = \frac{1}{2} m (V_i^2 - V_f^2)$

(1) $h = 0.12 m$