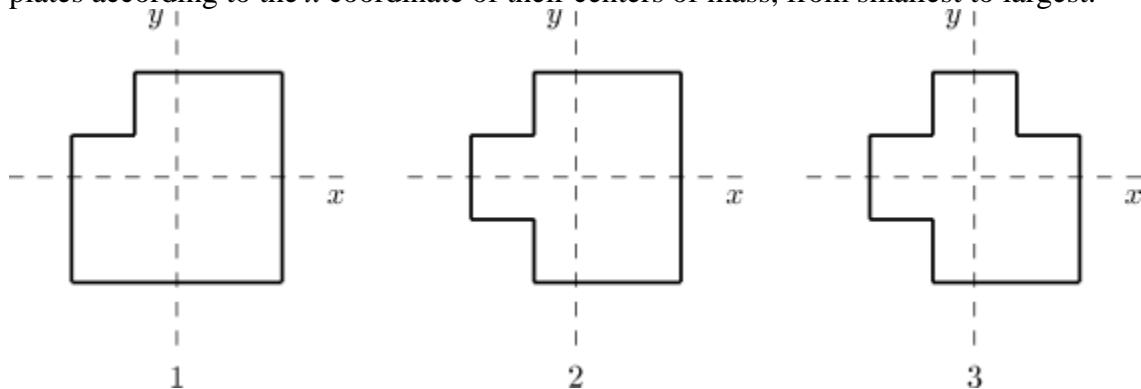


Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. A machinist starts with three identical square plates but cuts one corner from one of them, two corners from the second, and three corners from the third. Rank the three plates according to the  $x$  coordinate of their centers of mass, from smallest to largest.



- A) 1, 2, 3  
B) 1 and 2 tie, then 3  
C) 1, then 2 and 3 tie  
D) 3, 2, 1  
E) 1 and 3 tie, then 2
2. At the same instant that a 0.50-kg ball is dropped from 25 m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15 m/s. They move along nearby lines and pass each other without colliding. At the end of 2.0 s the height above Earth's surface of the center of mass of the two-ball system is:
- A) 2.9 m  
B) 4.0 m  
C) 5.0 m  
D) 7.1 m  
E) 10.4 m

Write the letter for the correct answer on the answer sheet. Write clearly.

3. Two boys, with masses of 40 kg and 60 kg, respectively, stand on a horizontal frictionless surface holding the ends of a light 10-m long rod. The boys pull themselves together along the rod. When they meet the 60-kg boy will have moved what distance?
- A) 4 m  
B) 5 m  
C) 6 m  
D) 10 m  
E) need to know the forces they exert
4. A 640-N hunter gets a rope around a 3200-N polar bear. They are stationary, 20 m apart, on frictionless level ice. When the hunter pulls the polar bear to him, the polar bear will move:
- A) 1.0 m  
B) 3.3 m  
C) 10 m  
D) 12 m  
E) 17 m
5. At the same instant that a 0.50-kg ball is dropped from 25 m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15 m/s. They move along nearby lines and pass without colliding. At the end of 2.0 s the magnitude of the acceleration of the center of mass of the two-ball system is:
- A)  $0.25g$   
B)  $0.50g$   
C)  $0.75g$   
D)  $g$   
E)  $g/0.75$
6. A light rope passes over a light frictionless pulley attached to the ceiling. An object with a large mass is tied to one end and an object with a smaller mass is tied to the other end. Starting from rest the heavier object moves downward and the lighter object moves upward with the same magnitude acceleration. Which of the following statements is true for the system consisting of the two objects?
- A) The center of mass remains at rest.  
B) The net external force is zero.  
C) The velocity of the center of mass is a constant.  
D) The acceleration of the center of mass is  $g$ , downward.  
E) None of the above statements are true.

Write the letter for the correct answer on the answer sheet. Write clearly.

7. The center of mass of a system of particles has a constant velocity if:
- A) the forces exerted by the particles on each other sum to zero
  - B) the external forces acting on particles of the system sum to zero
  - C) the velocity of the center of mass is initially zero
  - D) the particles are distributed symmetrically around the center of mass
  - E) the center of mass is at the geometric center of the system
8. At the same instant that a 0.50-kg ball is dropped from 25 m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15 m/s. They move along nearby lines and pass without colliding. At the end of 2.0 s the velocity of the center of mass of the two-ball system is:
- A) 11 m/s, down
  - B) 11 m/s, up
  - C) 15 m/s, down
  - D) 15 m/s, up
  - E) 20 m/s, down
9. Two 4.0-kg blocks are tied together with a compressed spring between them. They are thrown from the ground with an initial velocity of 35 m/s,  $45^\circ$  above the horizontal. At the highest point of the trajectory they become untied and spring apart. About how far below the highest point is the center of mass of the two-block system 2.0 s later, before either fragment has hit the ground?
- A) 12 m
  - B) 20 m
  - C) 31 m
  - D) Can't tell because the velocities of the fragments are not given.
  - E) Can't tell because the coordinates of the highest point are not given.
10. Block A, with a mass of 4 kg, is moving with a speed of 2.0 m/s while block B, with a mass of 8 kg, is moving in the opposite direction with a speed of 3 m/s. The center of mass of the two block-system is moving with a velocity of:
- A) 1.3 m/s in the same direction as A
  - B) 1.3 m/s in the same direction as B
  - C) 2.7 m/s in the same direction as A
  - D) 1.0 m/s in the same direction as B
  - E) 5.0 m/s in the same direction as A

**11.** The center of mass of a uniform disk of radius  $R$  is located:

- A) on the rim
- B) a distance  $R/2$  from the center
- C) a distance  $R/3$  from the center
- D) a distance  $2R/3$  from the center
- E) at the center

**12.** The center of mass of a system of particles remains at the same place if:

- A) it is initially at rest and the external forces sum to zero
- B) it is initially at rest and the internal forces sum to zero
- C) the sum of the external forces is less than the maximum force of static friction
- D) no friction acts internally
- E) none of the above

**13.** Which one of the following statements is true?

- A) the center of mass of an object must lie within the object
- B) all the mass of an object is actually concentrated at its center of mass
- C) the center of mass of an object cannot move if there is zero net force on the object
- D) the center of mass of a cylinder must lie on its axis
- E) none of the above

**14.** The center of mass of Earth's atmosphere is:

- A) a little less than halfway between Earth's surface and the outer boundary of the atmosphere
- B) near the surface of Earth
- C) near the outer boundary of the atmosphere
- D) near the center of Earth
- E) none of the above

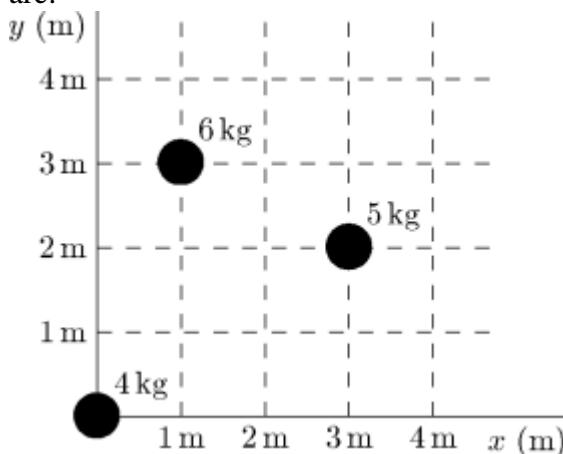
**15.** A system consists of two particles with masses of 2 kg and 4 kg, moving in opposite directions on the  $x$  axis. The velocity of the center of mass is  $(3 \text{ m/s})\hat{i}$ . The net momentum of the system:

- A) is zero
- B) is  $(6 \text{ kg} \cdot \text{m/s})\hat{i}$
- C) is  $(9 \text{ kg} \cdot \text{m/s})\hat{i}$
- D) is  $(12 \text{ kg} \cdot \text{m/s})\hat{i}$
- E) cannot be computed unless the velocities of the particles are given

**16.** Particle A has a mass of 1 kg and a speed of 3 m/s. Particle B has a mass of 2 kg. The speed of the center of mass of the two-particle system is 5 m/s. The greatest and least speed that particle B might have are:

- A) 6 m/s and 1 m/s
- B) 3 m/s and 6 m/s
- C) 0 and 3 m/s
- D) 0 m/s and 9 m/s
- E) 5 m/s and 6 m/s

**17.** The  $x$  and  $y$  coordinates of the center of mass of the three-particle system shown below are:



- A) 0,0
- B) 1.3 m, 1.7 m
- C) 1.4 m, 1.9 m
- D) 1.9 m, 2.5 m
- E) 1.4 m, 2.5 m

- 18.** The velocity of the center of mass of a two-particle system is  $(2 \text{ m/s})\hat{i}$  and the net momentum of the system is  $(8 \text{ kg} \cdot \text{m/s})\hat{i}$ . If the mass of one of the particles 3 kg the mass of the other is:
- A)** zero
  - B)** 1 kg
  - C)** 2 kg
  - D)** 3 kg
  - E)** 4 kg
- 19.** The center of mass of the system consisting of Earth, the Sun, and the planet Mars is:
- A)** closer to Earth than to either of the other bodies
  - B)** closer to the Sun than to either of the other bodies
  - C)** closer to Mars than to either of the other bodies
  - D)** at the geometric center of the triangle formed by the three bodies
  - E)** at the center of the line joining Earth and Mars
- 20.** Cart A, with a mass of 0.20 kg, travels on a horizontal air track at 3.0 m/s and hits cart B, which has a mass of 0.40 kg and is initially traveling away from A at 2.0 m/s. After the collision the center of mass of the two cart system has a speed of:
- A)** zero
  - B)** 0.33 m/s
  - C)** 2.3 m/s
  - D)** 2.5 m/s
  - E)** 5.0 m/s

Write the letter for the correct answer on the answer sheet. Write clearly.

## Answer Key

- 1.** E
- 2.** D
- 3.** A
- 4.** B
- 5.** D
- 6.** E
- 7.** B
- 8.** C
- 9.** B
- 10.** B
- 11.** E
- 12.** A
- 13.** E
- 14.** D
- 15.** D
- 16.** A
- 17.** C
- 18.** B
- 19.** B
- 20.** B

Write the letter for the correct answer on the answer sheet. Write clearly.