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Multiple choice questions

Answer all of the following questions. Read each question carefully. **Fill the correct bubble on your scantron sheet**. Each question has exactly one correct answer. All questions are worth the same amount of points.

1. A point mass m has kinetic energy KE_1 measured in an inertial frame R_1 and kinetic energy KE_2 measured in another inertial frame R_2. The velocity of R_2 with respect to R_1 is $\vec{v} \neq 0$.
   Which of the following is true for sure?

   A. $KE_2=KE_1$
   B. $KE_2=KE_1 + 1/2mv^2$
   C. $KE_2<KE_1$
   D. $KE_2>KE_1$
   E. $KE_2 \neq KE1$
   Not a good question since there is no answer (everyone got 1 point for this one). But here is what we can say (index 1 is for quantities measured in R_1 and index 2 for quantities measured in R_2)
   $$\vec{v}_1 = \vec{v}_2 + \vec{v}$$
   $$\frac{1}{2}mv_1^2 = \frac{1}{2}mv_2^2 + \frac{1}{2}mv^2 + m\vec{v}_2 \cdot \vec{v}$$
   $$KE_1 = KE_2 + \frac{1}{2}mv^2 + m\vec{v}_2 \cdot \vec{v}$$
   Depending on what $\vec{v}_2$ and $\vec{v}$ are, all of the above answers are possible.

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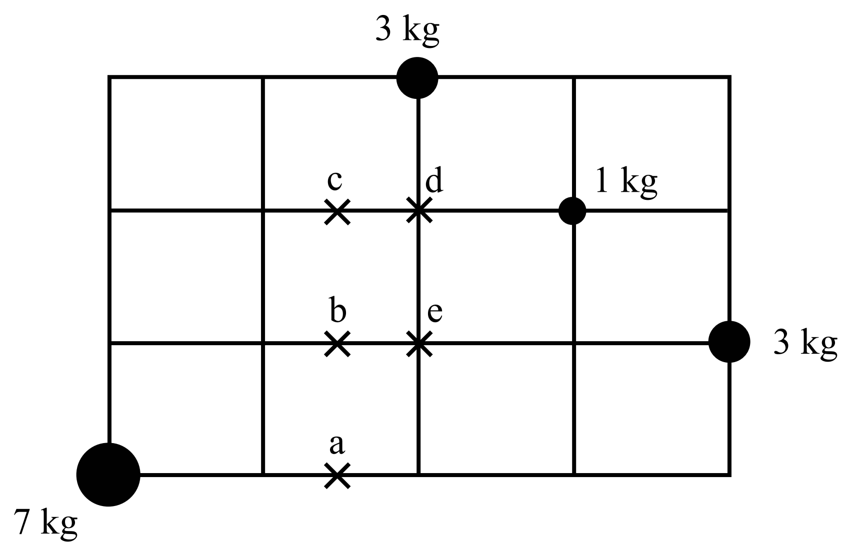
2. The center of mass of the system of particles shown in the diagram is at point



A. a
B. b The CM of the 3kg+3kg+1kg=7kg is at the location of the 1kg. The CM of the full set of masses is halfway between the 7kg and the 1kg mass locations
C. c
D. d
E. e

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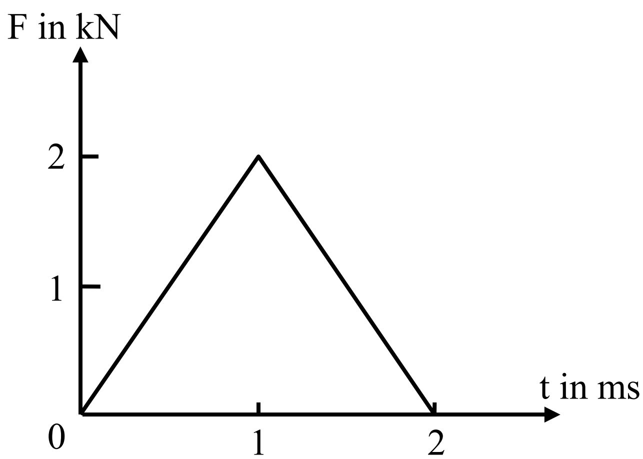
3. Using a mallet, you strike a ball of mass 0.50 kg that is initially at rest. The force F on the ball as a function of time is plotted in the figure. At t=2.0ms, the speed of the ball is



A. 10 m/s
B. 8.0 m/s
C. 6.0 m/s

D. 4.0 m/s

$$\Delta\vec{p} = \int \vec{F}dt$$

$$v_f = \frac{\int Fdt}{m} = \frac{2}{0.5} = 4\ m/s$$

E. 2.0 m/s

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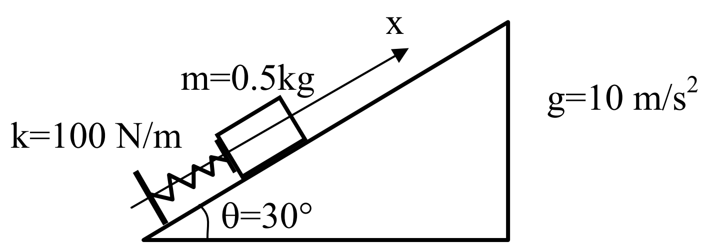
Questions 4 through 10 all refer to the same problem.

A block of mass m=0.5kg is initially at rest on a frictionless 30° incline as shown on the figure below. The block is resting against a massless spring of spring constant k=100N/m. The spring is not attached to the block. Displacements are measured along an x-axis directed up along the incline. Take the origin x=0 to be the location where the spring is not compressed. Since the spring is not attached to the block, the spring loses contact with the block for x>0.
Take g=10 m/s^2.



4. What is the location x_{eq} of the block at equilibrium?

A. -2.5 cm
$-kx_{eq} - mg\sin\theta = 0$

B. -4.33 cm
C. -5 cm
D. -7 cm
E. -10 cm

The block is displaced by an additional 4 cm down the incline from its equilibrium position and then released (in other words, the block is released at x=x_{eq}-4cm with no initial velocity).
In what follows, U(x) is the potential energy of the system block block+spring+Earth at position x along the incline.

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5. How do $U(x_{eq}$-4cm) and $U(x_{eq})$ compare?

   A. $U(x_{eq}\text{-4cm}) > U(x_{eq})$
   At the equilibrium position, $U(x_{eq})$ is a minimum
   B. $U(x_{eq}\text{-4cm}) < U(x_{eq})$
   C. $U(x_{eq}\text{-4cm}) = U(x_{eq})$
   D. Can't tell. There is not enough information.

6. After its release, as the block travels up the incline, what can you say about the total mechanical energy E_{mec} of the system block+spring+Earth?

   A. E_{mec} is constant.
   All forces that do work are conservative forces (namely the weight and the force by the spring)
   B. E_{mec} decreases as x increases.
   C. E_{mec} increases as x increases.
   D. From $x=x_{eq}$-4 cm to x=0 cm, E_{mec} increases. Then E_{mec} decreases as x increases.
   E. From x= x_{eq} -4 cm to x=0 cm, E_{mec} decreases. Then E_{mec} increases as x increases.

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7. After its release, what is the position x_{max} of the block up the incline when it comes momentarily to rest for the first time?

A. -1.5 cm
B. 1.5 cm
C. 1.95 cm

$$PE_f + KE_f = PE_i + KE_i$$

$$PE_f = mg\sin\theta x_{\max}$$

$$PE_i = mg\sin\theta(x_{eq} - 0.04) + \frac{1}{2}k(x_{eq} - 0.04)^2$$

$$KE_f = KE_i = 0$$

$$x_{\max} = (x_{eq} - 0.04) + \frac{k}{2mg\sin\theta}(x_{eq} - 0.04)^2$$

$$x_{\max} = -0.065 + \frac{100}{2\times 0.5\times 10\times 0.5}(-0.065)^2$$

D. 4 cm
E. 10 cm

8. How do $U(x_{eq}$-4cm) and $U(x_{max})$ compare?

A. $U(x_{eq}$-4cm) > $U(x_{max})$
B. $U(x_{eq}$-4cm) < $U(x_{max})$
C. $U(x_{eq}$-4cm) = $U(x_{max})$
Since the E_{mec} is constant and at x_{max} and x_{eq}-4cm the KE is 0.
D. Can't tell. There is not enough information.

9. As the block travels up the incline, where is its kinetic energy maximum?

A. at x_{max}
B. at x_{eq}
Since E_{mec}=PE + KE is constant, KE is maximum where PE is minimum.
C. at the origin x=0
D. at some location between x=0 and x_{max}
E. at some location between x_{eq}-4cm and x_{eq}

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10. As the block travels up the incline, where is the magnitude of its acceleration maximum?

A. at x_{max}
B. at x_{eq}
C. at the origin x=0
D. at x_{eq}-4cm

$$|\vec{a}| = \left| -\frac{k}{m}x - g\sin\theta \right| \; if \; x_{eq} - 0.04m \leq x \leq 0$$

$$|\vec{a}| = g\sin\theta \; if \; x \geq 0$$

x_{eq}-4cm gives the largest acceleration.

E. at some location between x_{eq}-4cm and x_{eq}

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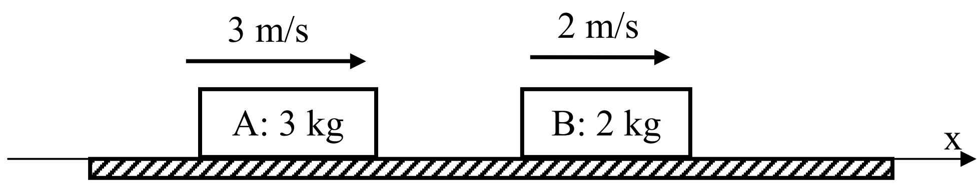
Questions 11 through 17 all refer to the same problem.

On a frictionless horizontal track, block A of mass 3kg collides with block B of mass 2 kg. Before the collision, the velocity of A is $\vec{v}_A = 3\hat{x}\, m/s$ and the velocity of B is $\vec{v}_B = 2\hat{x}\, m/s$ as indicated on the figure below.
After the collision, it is observed that A and B have the same velocity $\vec{v}$.



11. During the collision, what is the direction of the net force on A?

A. $\hat{x}$

B. $-\hat{x}$
Force on B by A

C. Undefined, since the net force is 0

12. During the collision, what can you say about the magnitude $|\vec{p}_A|$ of the momentum of A?

A. $|\vec{p}_A|$ increases

$|\vec{p}_A|$ decreases

B. The momentum of A and the net force on A have opposite direction and $\Delta\vec{p}_A = \int \vec{F}^A{}_{net}\, dt$

C. $|\vec{p}_A|$ stays the same

D. Can't say anything. There is not enough information.

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13. What is the velocity of the center of mass of the system A+B before the collision (in m/s)?

A. 0

B. $2\hat{x}$

C. $2.5\hat{x}$

D. $2.6\hat{x}$

$$\vec{v}_{CM} = \frac{m_A \vec{v}_A + m_B \vec{v}_B}{m_A + m_B}$$

E. $5\hat{x}$

14. What is the velocity $\vec{v}$ of A and B after the collision (in m/s)?

A. 0

B. $2\hat{x}$

C. $2.5\hat{x}$

D. $2.6\hat{x}$

The velocity of the center of mass doesn't change (the net force on A+B is 0). After the collision, A and B have the same velocity as the center of mass since they form one piece.

E. $5\hat{x}$

15. In the center of mass frame, what is the kinetic energy of the system <u>before</u> the collision (in Joules)?

A. 0

B. 0.6

$$KE = \frac{1}{2} m_A (\vec{v}_A - \vec{v}_{CM})^2 + \frac{1}{2} m_B (\vec{v}_B - \vec{v}_{CM})^2$$

$$KE = \frac{1}{2} 3(3-2.6)^2 + \frac{1}{2} 2(2-2.6)^2$$

C. 1.2

D. 17.5

E. 35

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16. In the center of mass frame, what is the kinetic energy of the system after the collision (in Joules)?

    A. 0
    A and B have the same velocity as the center of mass. In the center of mass frame, the velocity of A and B is 0.
    B. 0.6
    C. 1.2
    D. 17.5
    E. 35

17. Is the collision an elastic collision?

    A. No in all inertial frames.
    B. Yes in all inertial frames.
    If some energy is lost in one frame, it can't be conserved in some other frame.
    C. Yes in the center of mass frame. No in an inertial frame fixed with respect to the horizontal track.
    D. No in the center of mass frame. Yes in an inertial frame fixed with respect to the horizontal track.
    E. Can't tell. There is not enough information. N