Physics
Quiz # 12

Date Given: June 30, 2022
Date Due: July 7, 2022

Q1. (1 point) Select the one true statement from the four choices offered below:

(a) Work and kinetic energy are vector quantities.

(b) Momentum is a vector quantity and kinetic energy is a scalar quantity.

(c) Momentum is a scalar quantity and kinetic energy is a vector quantity.

(d) Momentum and kinetic energy are vector quantities.

Answer:
(b) Momentum is defined as the product of mass with velocity, $G = mv$, so it is a vector with the same direction as the velocity. Kinetic energy is defined as $T = (1/2)mv^2$, mathematically obtained as the scalar product of velocity with velocity, $T = (1/2)m\boldsymbol{v} \cdot \boldsymbol{v}$, so it is a scalar quantity.

Q2. (1 point) In the case of the direct central impact of two spheres in collinear motion that collide with each other in an elastic impact:

(a) Linear momentum is conserved, but kinetic energy is not conserved.

(b) Linear momentum and kinetic energy are both conserved.

(c) Kinetic energy is conserved, but linear momentum is not conserved.

(d) Neither linear momentum nor kinetic energy is conserved.

Answer:
(b) In an elastic collision between two bodies the total kinetic energy of the two bodies after the collision is equal to their total kinetic energy before the collision and the total linear momentum after the collision is equal to the total linear momentum after the collision.

Q3. (2 points) Determine the impulse of the force shown in Figure 1 (a and b) in the horizontal direction over interval of time from $t = 0$ to $t = 3$s.

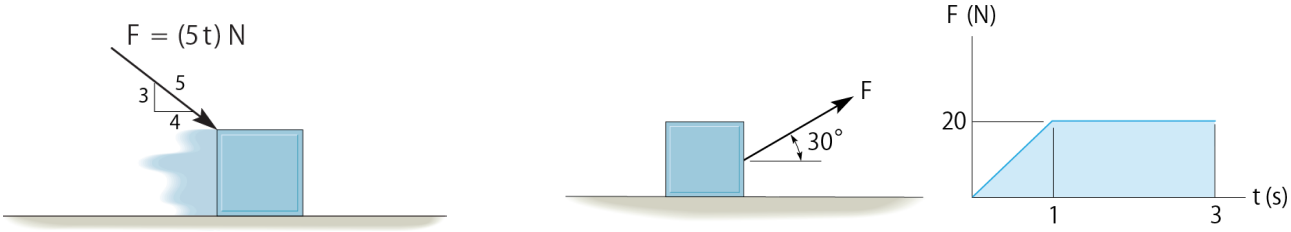

Figure 1: Illustration to Question 3.

Answer:

(a) $I_x = \frac{4}{5}\int_0^3 5t\mathrm{d}t = 18$ N · s.

(b) $I_x = \cos 30^\circ \times \text{Area} = \frac{\sqrt{3}}{2} \times \left(\frac{1}{2}20 \times 1 + 20 \times 2\right) = 25\sqrt{3} = 43.3013$ N · s.

Q4. (3 points) Determine the linear momentum of the 10-kg block shown in Figure 2 (a, b, and c) in the direction of motion.

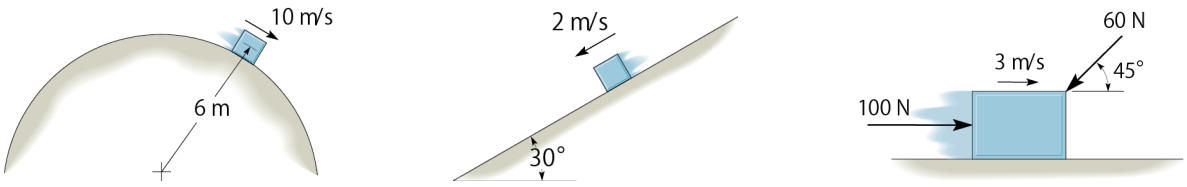

Figure 2: Illustration to Question 4.

Answer:

(a) $G = 10\text{kg} \times 10\text{m/s} = 100\ \text{kg} \cdot \text{m/s}.$

(b) $G = 10\text{kg} \times 2\text{m/s} = 20\ \text{kg} \cdot \text{m/s}.$

(c) $G = 10\text{kg} \times 3\text{m/s} = 30\ \text{kg} \cdot \text{m/s}.$

Q5. (2 points) The 0.5-kg ball strikes the rough ground and rebounds with the velocities as shown in Figure 3. Determine the magnitude of the impulse the ground exerts on the ball. Assume that the ball does not slip when it strikes the ground, and neglect the size of the ball and the impulse produced by the weight of the ball.

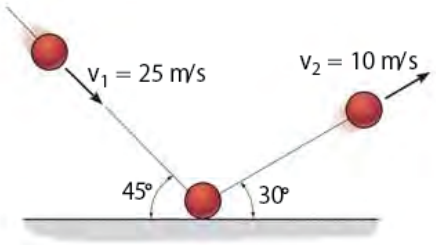

Figure 3: Illustration to Question 5.

Answer:

(a) Let $I_x = \int_{t_1}^{t_2} F_x \mathrm{d}t$ be the impulse of the contact force in x direction. Taking into account the motion directions, we can write $mv_{1x} + I_x = mv_{2x}$. Then, from $mv_1 \cos 45^\text{o} + I_x = mv_2 \cos 30^\text{o}$, we get $I_x = mv_2 \cos 30^\text{o} - mv_1 \cos 45^\text{o} \approx -4.509\ \text{N} \cdot \text{s}$.

(b) Let $I_y = \int_{t_1}^{t_2} F_y \mathrm{d}t$ be the impulse of the contact force in y direction. Taking into account the motion directions, we can write $-mv_{1y} + I_y = mv_{2y}$. Then, from $-mv_1 \sin 45^\text{o} + I_y = mv_2 \sin 30^\text{o}$, we get $I_y = mv_2 \sin 30^\text{o} + mv_1 \sin 45^\text{o} \approx 11.339\ \text{N} \cdot \text{s}$.

(c) Finally, the magnitude of the contact impulse $I = \sqrt{I_x^2 + I_x^2} \approx 12.202\ \text{N} \cdot \text{s}$.