Physics
Quiz # 13

Date Given: July 7, 2022
Date Due: July 14, 2022

Q1. (1 point) A necessary condition for conservation of angular momentum of a particle is:

(a) The distance between the particle and the point about which the angular momentum is calculated must be zero.

(b) The kinetic energy of the particle must be zero.

(c) The resultant moment about a fixed point of all the forces acting on the particle must be zero.

(d) The linear momentum of the particle must be zero.

Answer:
(c) The resultant moment about a fixed point of all the forces acting on the particle must be zero.

Q2. (1 point) For motion of a particle under the influence of a central force (a force $\boldsymbol{F}$ directed parallel to vector $\boldsymbol{r}$):

(a) Angular momentum is conserved.

(b) Linear momentum is conserved.

(c) The net force acting on the particle must be zero.

(d) Kinetic energy is conserved.

Answer:
(a) Angular momentum is conserved in central force motion because a central force does not produce a moment about the point about which the particle is rotating.

Q3. (2 points) The 2-kg particle A has the velocity shown in Figure 1 (a and b).

(a) Determine its angular momentum $\boldsymbol{H}_O$ about point O (left figure).

(b) Determine its angular momentum $\boldsymbol{H}_P$ about point P (right figure).

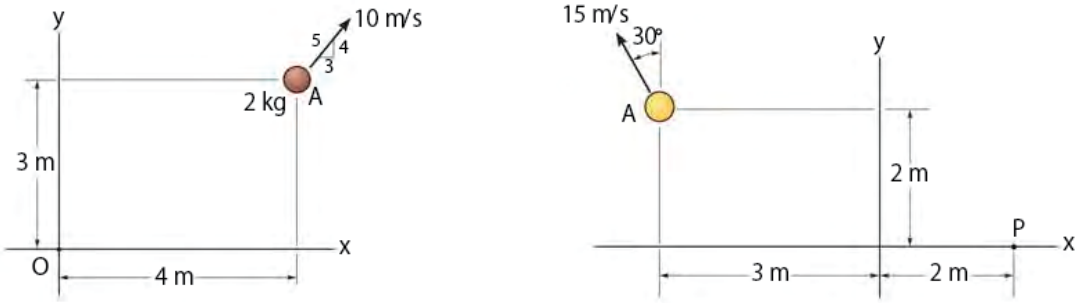

Figure 1: Illustration to Question 3.

Answer:

(a) Here, $\boldsymbol{r} = (4\boldsymbol{i}+3\boldsymbol{j})$m and $\boldsymbol{v} = 10\{(3/5)\boldsymbol{i}+(4/5)\boldsymbol{j}\}$m/s. Therefore $\boldsymbol{H}_O = m\boldsymbol{r}\times\boldsymbol{v} = 28\boldsymbol{k}$ N·m·s.

(b) Here, $\boldsymbol{r} = (-5\boldsymbol{i}+2\boldsymbol{j})$m and $\boldsymbol{v} = 10\{-\sin 30^\circ\boldsymbol{i}+\cos 30^\circ\boldsymbol{j}\}$m/s. Therefore $\boldsymbol{H}_P = m\boldsymbol{r}\times\boldsymbol{v} = -99.9038\boldsymbol{k}$ N·m·s.

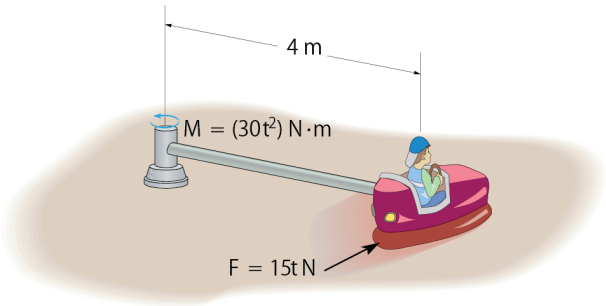

Figure 2: Illustration to Question 4.

Q4. (2 points) If the rod of negligible mass is subjected to a couple moment of $M = 30t^2$ N · m (see Figure 2) and the engine of the car supplies a traction force of $F = 15t$ N to the wheels, where t is in seconds, determine the speed of the car at the instant $t = 5$ s. The car starts from rest. The total mass of the car and rider is 150 kg. Neglect the size of the car.

Answer: The free-body diagram of the system is shown in Figure 3 Since the moment reaction M_s has no component about the z axis, the force reaction F_s acts through the z axis, and the line of action of W and N are parallel to the z axis, they produce no angular impulse about the z axis.

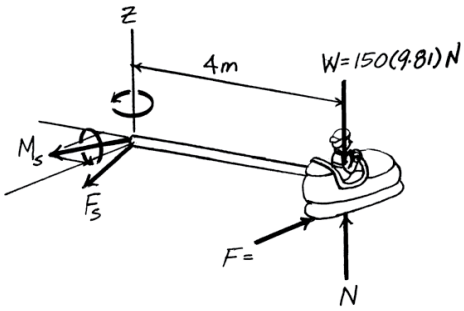

Figure 3: Illustration to Question 4.

Therefore, we can apply the principle of angular impulse and momentum:

$$(H_1)_z + \sum \int_{t_1}^{t_2} M_z \mathrm{d}t = (H_2)_z$$

where $(H_1)_z = 0$ since the system is initially at rest, $(H_2)_z = dmv = 4 \times 150v$, and the total moment about z axis is $M + Fd$. Thus

$$\int_0^5 (30t^2 + 4 \times 15t)\mathrm{d}t = 600v$$

or

$$(30\frac{5^3}{3} + 60\frac{5^2}{2}) = 600v \quad \Longrightarrow v = 3.333\mathrm{m/s}$$