

7 points

Question 5: Short Answer

- (a)(i) For indicating “Frame C” with correct reasoning about the magnitude of the torque being the greatest **1 point**

Accept **one** of the following:

- This is the instant when the lever arm is greatest.
- This is when the angle between radius vector and weight force vector is most perpendicular.

For correctly relating torque and angular acceleration: $\alpha \propto \tau$ **1 point**

Example Response

The angular acceleration is greatest in Frame C because angular acceleration is proportional to torque, and in Frame C the gravitational force vector is directed perpendicular to the rod (lever arm) which means this is where the torque will be the greatest.

- (a)(ii) For indicating “Frame E” with correct reasoning **1 point**

Accept **one** of the following:

- Work or energy (e.g., this is when the maximum work has been done on the system by gravity.)
- Angular momentum (e.g., the torque due to gravity is clockwise the entire time, causing the rod to gain angular momentum.)
- Kinematics (e.g., the rod speeds up the entire time.)

Example Response

The rotational kinetic energy is greatest in Frame E because this is where the rod-sphere system has the greatest rotational speed since the torque has been in the same direction as the motion the entire time.

Total for part (a) 3 points

- (b)(i) For a multistep derivation that begins with conservation of energy **1 point**

$$E_i = E_f \quad \text{OR} \quad \Delta E = 0 \quad \text{OR} \quad U_{gi} + K_i = U_{gf} + K_f$$

For indicating the change in height is equal to $\frac{3}{2}L$ **1 point**

$$\Delta y = \frac{3}{2}L$$

For an answer consistent with the height change indicated previously in the response **1 point**

$$K_f = \frac{3}{2}MgL$$

Scoring Note: A correct answer of $K_f = \frac{3}{2}MgL$ with no supporting work can earn only this point.

Example Response

$$\begin{aligned} E_i &= E_f \\ U_{gi} + K_i &= U_{gf} + K_f \\ \Delta K &= U_{gi} - U_{gf} \\ \Delta K &= Mg\Delta y \\ \Delta y &= \frac{3L}{4} + \frac{3L}{4} = \frac{3}{2}L \\ \Delta K &= \frac{3}{2}MgL \end{aligned}$$

- (b)(ii) For indicating that the gravitational force is the external force that does work on the rod-sphere system **1 point**

Example Response

The rod and sphere gain kinetic energy due to the positive work done by the gravitational force, which is an external force for the rod-sphere system.

Total for part (b) 4 points

Total for question 5 7 points