

21.4: Translation and Rotation of a Rigid Body Undergoing Fixed Axis Rotation

For the special case of rigid body of mass m , we showed that with respect to a reference frame in which the center of mass of the rigid body is moving with velocity \vec{V}_{cm} all elements of the rigid body are rotating about the center of mass with the same angular velocity $\vec{\omega}_{cm}$. For the rigid body of mass m and momentum $\vec{p} = m\vec{V}_{cm}$ the translational equation of motion is still given by Equation (21.2.1), which we repeat in the form

$$\vec{F}^{\text{ext}} = m\vec{A}_{cm}$$

For fixed axis rotation, choose the z -axis as the axis of rotation that passes through the center of mass of the rigid body. We have already seen in our discussion of angular momentum of a rigid body that the angular momentum does not necessarily point in the same direction as the angular velocity. However we can take the z -component of Equation (21.3.28)

$$\tau_{cm,z}^{\text{ext}} = \frac{dL_{cm,z}^{\text{spin}}}{dt}$$

For a rigid body rotating about the center of mass with $\vec{\omega}_{cm} = \omega_{cm,z}\hat{k}$ the z -component of angular momentum about the center of mass is

$$L_{cm,z}^{\text{spin}} = I_{cm}\omega_{cm,z}$$

The z -component of the rotational equation of motion about the center of mass is

$$\tau_{cm,z}^{\text{ext}} = I_{cm} \frac{d\omega_{cm,z}}{dt} = I_{cm}\alpha_{cm,z}$$

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