

PROBLEM 12.71

PROBLEM: The airplane in Problem 12.70 is shown with its propellers rotating and its engine cylinders, both, accelerated rotation. The free-body diagram will now include:

Given: Calculated for the free-body diagram, generalized coordinates will now include, with the free-body diagram, that an engine cylinder has rotational energy

associated with its rotation about:

rotation about the horizontal axis as shown, e.g., the acceleration of rotation is constant, $\alpha = 1000 \text{ rad/s}^2$. There is no change in rotation.



Assume: The following energy is:

$$\begin{aligned} \text{KE}_{\text{rot}} &= \frac{1}{2} I \omega^2 = \frac{1}{2} (2000 \text{ kg} \cdot \text{m}^2) \omega^2 = \frac{1}{2} \left(\frac{1 \text{ kg}}{1 \text{ kg}} \right) \left(\frac{1 \text{ m}^2}{1 \text{ m}^2} \right) \omega^2 \\ &= 1000 \omega^2 \text{ J} \end{aligned} \quad \text{Eq. 1}$$

The generalized potential energy is:

$$\begin{aligned} \text{PE}_{\text{rot}} &= 1000 \omega^2 \text{ J} = 1000 \left(\frac{1 \text{ kg}}{1 \text{ kg}} \right) \left(\frac{1 \text{ m}^2}{1 \text{ m}^2} \right) \omega^2 \\ &= 1000 \omega^2 \text{ J} \end{aligned} \quad \text{Eq. 2}$$

Let: The change in kinetic energy is related to the initial and final values (Eq. 1):

$$\Delta \text{KE}_{\text{rot}} = \frac{1}{2} I (\omega_f^2 - \omega_i^2)$$

Thus, solving for ω_f^2 and substituting Eq. 1:

$$\begin{aligned} \omega_f^2 &= \frac{2 \Delta \text{KE}_{\text{rot}}}{I} + \omega_i^2 \\ &= \frac{2 \cdot (1000 \text{ J})}{2000 \text{ kg} \cdot \text{m}^2} \left(\frac{1 \text{ kg}}{1 \text{ kg}} \right) \left(\frac{1 \text{ m}^2}{1 \text{ m}^2} \right) + (10 \text{ rad/s})^2 \\ &= 10.1 \text{ rad/s}^2 \end{aligned}$$

$$\omega_f = 10.05 \text{ rad/s} \quad \text{Eq. 3}$$

∴ For part (b), the rotating components are ignored.

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Shasha Hu



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