MECH 230 Dynamics
Homework 6

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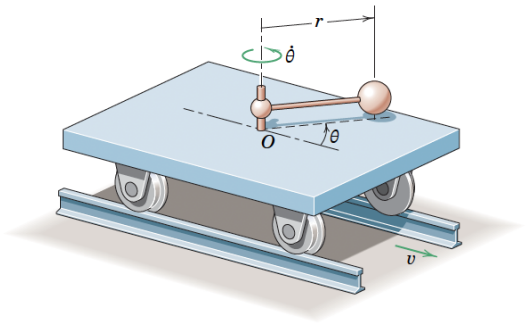
Due Wednesday October 23, 2024

1. Read the problem statement of MKB 4/023.

4/23 The small car, which has a mass of 20 kg, rolls freely on the horizontal track and carries the 5-kg sphere mounted on the light rotating rod with $r = 0.4$ m. A geared motor drive maintains a constant angular speed $\dot{\theta} = 4$ rad/s of the rod. If the car has a velocity $v = 0.6$ m/s when $\theta = 0$, calculate v when $\theta = 60°$. Neglect the mass of the wheels and any friction.



PROBLEM 4/23

2. Let $\mathbf{E}_x$ point parallel to the rails, $\mathbf{E}_z$ point vertically upwards, and $\mathbf{E}_y$ complete the right handed triad. Here, O is not a fixed point, so it cannot be our origin. Name the car body 1 and the sphere body 2, and take the fixed origin A to be such that

$$\mathbf{r}_1 = x\mathbf{E}_x,$$
$$\mathbf{r}_1 = \mathbf{r}_1 + r\mathbf{e}_r.$$

3. Calculate $\mathbf{v}_1$, $\mathbf{a}_1$, $\mathbf{v}_2$ and $\mathbf{a}_2$.
4. Draw the free body diagram of the combined system of the car and the sphere.

5. Show that the linear momentum of the system along $\mathbf{E}_x$ is conserved. Use this information to solve for $\dot{x}(t)$.
6. Consider the system of the ball alone and solve for the tension in the rod as a function of time.
7. Calculate the power of this tension force. This is the power supplied by the motor at O.
8. Find an expression for the total kinetic energy of the system. (Please do not replace values for the angular velocities of the masses. Use the symbols $m_1 = 20$ kg and $m_2 = 5$ kg.
9. Calculate the angular momentum of the system about the fixed origin A.