Session #10
Recitation on 3D Mechanisms
Journal Bearings
Email From Students

• For Tuesday, can you go over an example with using 3D HTM?
• I've been working with the homework some, and I guess there are three sticking points for the second problem. I can describe the constraints in words, but then I run into trouble
  1) describing the constraints with equations rather than words
  2) describing those equations as matrices
  3) using those matrices to create a Mathcad file
Simulating an R Joint

\[
R_u(u, \phi) \equiv \begin{bmatrix}
(u_1)^2 \cdot (1 - \cos(\phi)) + \cos(\phi) & u_1 \cdot u_2 \cdot (1 - \cos(\phi)) - u_3 \cdot \sin(\phi) & u_1 \cdot u_3 \cdot (1 - \cos(\phi)) + u_2 \cdot \sin(\phi) & 0 \\
u_1 \cdot u_2 \cdot (1 - \cos(\phi)) + u_3 \cdot \sin(\phi) & (u_2)^2 \cdot (1 - \cos(\phi)) + \cos(\phi) & u_2 \cdot u_3 \cdot (1 - \cos(\phi)) - u_1 \cdot \sin(\phi) & 0 \\
u_1 \cdot u_3 \cdot (1 - \cos(\phi)) - u_2 \cdot \sin(\phi) & u_2 \cdot u_3 \cdot (1 - \cos(\phi)) + u_1 \cdot \sin(\phi) & (u_3)^2 \cdot (1 - \cos(\phi)) + \cos(\phi) & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

\[
R_{pu}(p, u, \phi) \equiv T(p_1, p_2, p_3) \cdot R_u(u, \phi) \cdot T(-p_1, -p_2, -p_3)
\]
Example Problem

Problem 11.10 (McPherson Suspension Mechanism)

For the following data, first solve for the data not given. Then find

1. \( P_{2x}, P_{2y}, \alpha, \beta, \text{ and } \gamma \) while moving \( P_{2z} \) from 165.0 to -15.0 with \( \Delta P_{2z} = -10.0 \).

2. \( P_{2x}, P_{2y}, u_x, u_y, u_z \) and \( \phi \) while moving \( P_{2z} \) from 165.0 to -15.0 with \( \Delta P_{2z} = -10.0 \).

\[
\begin{align*}
P_1 &= (0, 669.5706, 45.0) \\
A_0 &= (33.69279, 342.80490, 7) \\
A_1 &= (-1.8532, 653.5278, -54.7) \\
U &= (0.9501599, 0.09522648, -?) \\
B_0 &= (106.0, 290.0, 90.0) \\
B_1 &= (133.0838, 592.8394, 48.2735) \\
D_1 &= (0.0189, 571.1713, 46.0154) \\
E_1 &= (3.8, ?, ?) \\
C_0 &= (10.0, 510.0, 583.0)
\end{align*}
\]

Note:
1. \( \overrightarrow{A_0A_1} \) is perpendicular to the axis vector \( U \).
2. \( U \) is the direction cosine vector of the axis.
3. Point \( E_1 \) is on the straight line \( \overrightarrow{C_0C_1} \) in space.

Applications of Bearings

Figures of automotive parts removed for copyright reasons.
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• Advantages (compared to rolling element bearings)
  – Require less space
  – Are quieter in operation
  – Are lower in cost
  – Greater Rigidity
  – Longer life

• Disadvantages (compared to rolling element bearings)
  – More friction therefore more power wasted
  – Stringent requirements on supply of lubricant
    • Must stay clean
    • Must not be interrupted
    • Temperature must be controlled
Say a railroad tank car creates the downward force \( W \). The projected area of the partial bearing was \( A \). Tower observed that the gauge pressure measured from the “lubricator hole” was about \( 2W/A \).

Couette Flow
Poiseuille Flow

Pressure drops linearly

Mass flow

$h$

$\mu$
What is the flow rate of fluid past line $A$?
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How does the torque applied to maintain a constant rotation rate depend on $\mu$ and $c_d$? (assume full film lubrication with a Newtonian fluid)

1) Linearly proportional to the product
2) Linearly proportional to the ratio
3) Some other dependence
4) I don’t know
Which statement is true regarding the rate of fluid flow past line $A$ and the fluid flow past line $B$?

1) They are essentially the same
2) $A < B$
3) $A > B$
4) I don’t know
Which statement is true regarding the rate of fluid flow past line $A$ and the fluid flow past line $B$ due to Couette flow only?

1) They are essentially the same
2) $A < B$
3) $A > B$
4) I don’t know
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Sketch the pressure distribution near the smallest part of the gap.

rotation

$e = \text{eccentricity}$
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rotation

Where would you apply a load to keep this shaft in equilibrium?

e = eccentricity
Concept Question

When the bearing is under load, what is the relative position of the shaft and block?

1. [Image 1]
2. [Image 2]
3. [Image 3]
4. [Image 4]
Sommerfeld Number

\[ S = \left( \frac{r}{c} \right)^2 \frac{\mu N}{P} \]

Load per unit of projected bearing area
Eccentricity Versus Design

Figure removed for copyright reasons.
Source: Shigley and Mischke, Figure 12-14.
Graph of minimum film-thickness variable and eccentricity ratio.
Next Steps

• Next session Thursday 16 MAR
  – Rolling element bearings (Amy Smith)
• Exam #1 next Tuesday