

Machine Design Final Exam

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```
[1]: # Notebook Preamble
import sympy as sp
import matplotlib.pyplot as plt
from IPython.display import display

plt.style.use('maroon_ipynb.mplstyle')
```

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1.1 Given 3

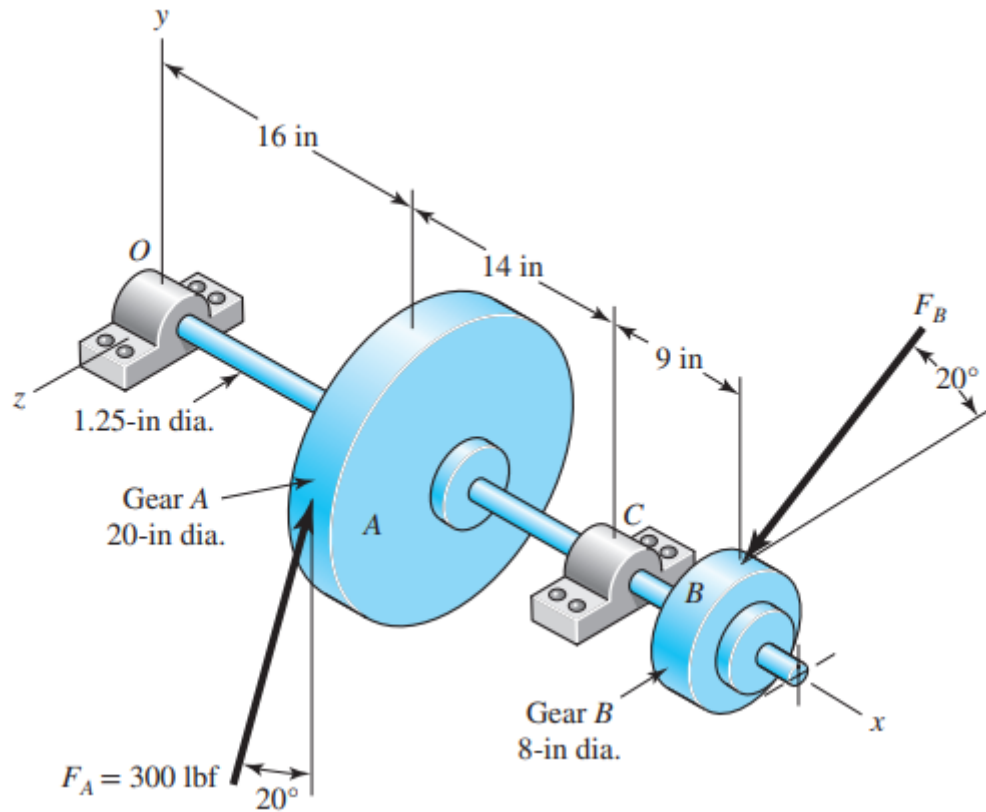
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1 Problem 3-83

1.1 Given



A gear reduction unit uses the countershaft shown in the figure above. Gear A receives power from another gear with a transmitted force F_A applied at the 20° pressure angle as shown. The power is transmitted through the shaft and delivered through gear B through a transmitted force F_B at the pressure angle shown.

1.2 Find

- Determine the force F_B , assuming the shaft is running at a constant speed.
- Find the bearing reaction forces, assuming the bearings act as simple supports.
- Draw a shear-force and bending moment diagrams for the shaft. If needed, make one set for the horizontal plane and another set for the vertical plane.
- At the point of maximum bending moment, determine the bending stress and the torsional shear stress.
- At the point of maximum bending moment, determine the principal stresses and the maximum shear stress.

1.3 Solution

1.3.1 Part A and Part B

F_B and the reaction forces may be found by summing the forces and taking the moments about the point O .

```
[2]: # Using matrices takes less thinking and more letting python do the work.
Oy, Oz, Cy, Cz, F_B = sp.symbols('O_y O_z C_y C_z F_B')
zero = sp.ZeroMatrix(3, 1)
F_A_mat = sp.Matrix([0, 300*sp.cos(sp.rad(20)), -300*sp.sin(sp.rad(20))])
F_B_mat = sp.Matrix([0, -F_B*sp.sin(sp.rad(20)), F_B*sp.cos(sp.rad(20))])
O = sp.Matrix([0, Oy, Oz])
C = sp.Matrix([0, Cy, Cz])

# Sum forces
sys1 = sp.Eq(O + F_A_mat + F_B_mat + C, zero)

# Sum moments about O
rA = sp.Matrix([16, 0, 10])
rC = sp.Matrix([16 + 14, 0, 0])
rB = sp.Matrix([16 + 14 + 9, 4, 0])
sys2 = sp.Eq(rA.cross(F_A_mat) + rC.cross(C) + rB.cross(F_B_mat), zero)

sol = sp.solve([sys1, sys2], dict=True)[0]
for key, value in sol.items():
    display(sp.Eq(key, value.n())) # lbf
```

$$C_y = 183.118820416782$$

$$C_z = -861.477082334154$$

$$F_B = 750.0$$

$$O_y = -208.511499158303$$

$$O_z = 259.313659742423$$

The reaction forces above assume all positive directions.