Machine Design Final Exam

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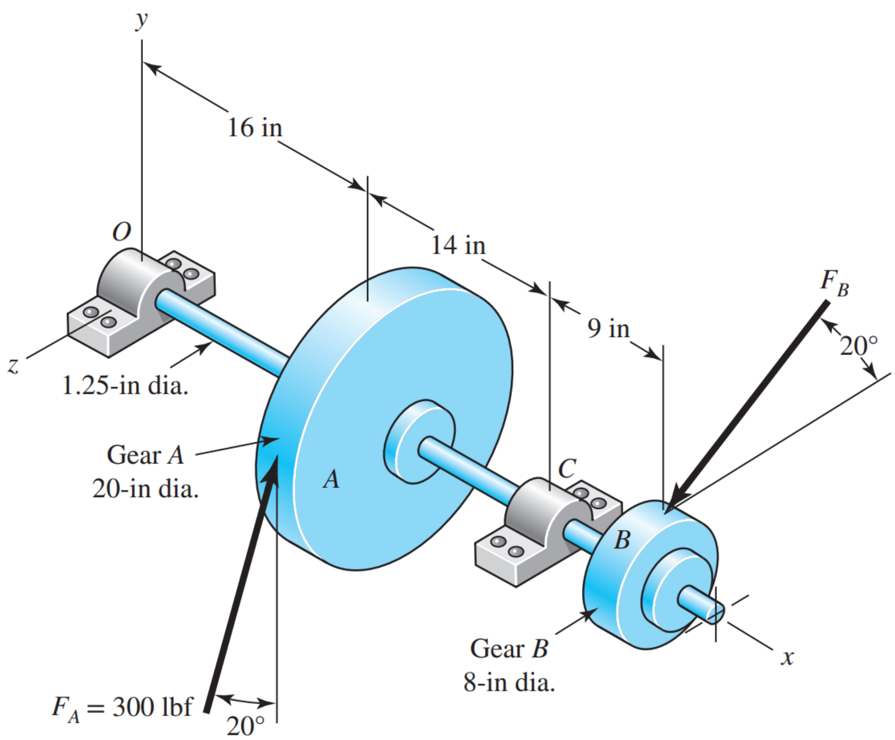
[1]:
```
# Notebook Preamble
import sympy as sp
import matplotlib.pyplot as plt
from IPython.display import display

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

Contents

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

a. Determine the force F_B, assuming the shaft is running at a constant speed.
b. Find the bearing reaction forces, assuming the bearings act as simple supports.
c. 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.
d. At the point of maximum bending moment, determine the bending stress and the torsional shear stress.
e. 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
```

$C_y = 183.118820416782$

$C_z = -861.477082334154$

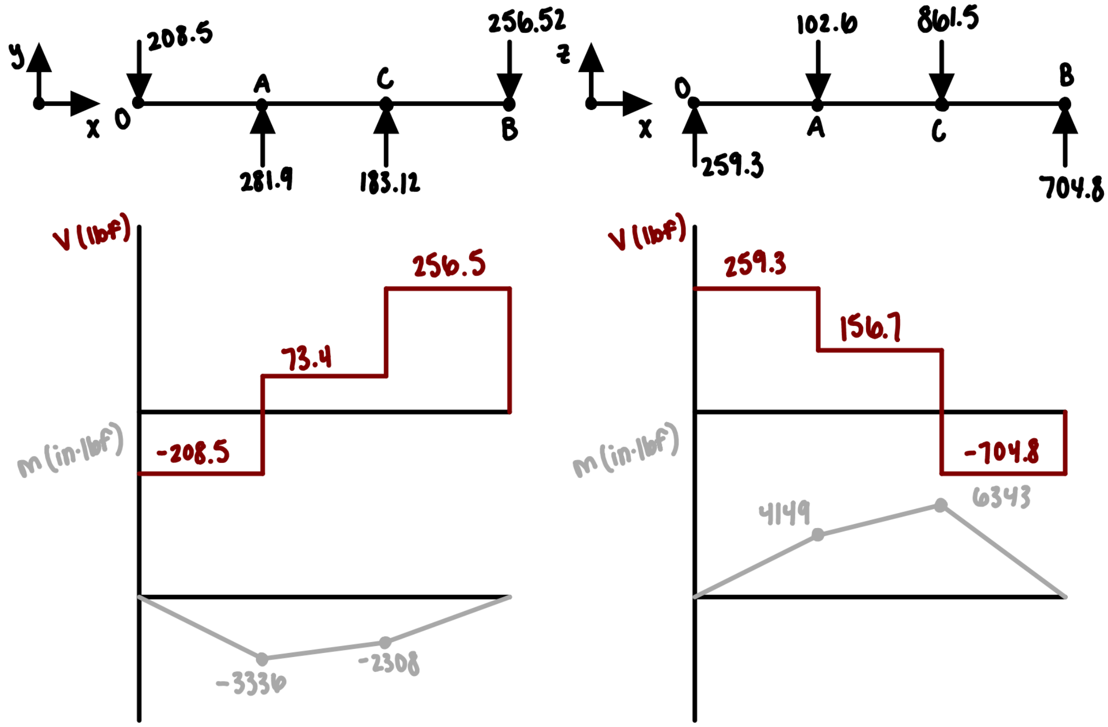
$F_B = 750.0$

$O_y = -208.511499158303$

$O_z = 259.313659742423$

The reaction forces above assume all positive directions.

1.3.2 Part C


y
x
O
208.5
A
C
256.52
B
281.9
183.12
z
x
O
102.6
861.5
A
C
B
259.3
704.8
V (lbf)
m (in·lbf)
-208.5
73.4
256.5
-3336
-2308
V (lbf)
m (in·lbf)
259.3
156.7
-704.8
4149
6343