

**ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
PRARIE VIEW A&M UNIVERSITY**

**MCEG 4043 MACHINE DESIGN II
FALL 2020 SEMESTER**

NAME OF INSTRUCTOR: Dr. Jaejong Park

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
MCEG 4043 MACHINE DESIGN II
FALL 2020**

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I. COURSE SYLLABUS IN ABET FORMAT

Department of Mechanical Engineering MCEG 4043 Machine Design

- 1. Course Number & Name:** MCEG 4043, Machine Design II
- 2. Credits and Contact Hours:** 3-Credit Hours, 3-Contact Hours
- 3. Instructor and Coordinator:** Dr. Jaejong Park
- 4. Textbook:** Budynas, R. G. and Nisbett, J. K., Shigley's Mechanical Engineering Design, 10th edition, McGraw-Hill Book Company, ISBN 978-0-07-339820-4
- Supplemental Materials:** None

5. Specific Course Information

a. 2019-20 Catalog Description

MCEG 4043 Machine Design II: This is a design course featuring a design project using strength of materials, kinematics of machines, machine element design (e.g. gears and shafts), and CAD.

Prerequisites: MCEG3043 and MCEG3053 (may be taken concurrently)

Co-requisite: None

Course Designation: Required Course

6. Specific Goals for the Course

a. Specific Outcomes of Instruction

After completion of this course, the students should be able to apply the design processes to mechanical elements, using contemporary design standards and tools and have developed the following:

- 1. Skills for mechanical element design
- 2. Ability to analyze mechanical engineering elements
- 3. Knowledge for various machine elements
- 4. Ability to complete a mechanical design project

b. ABET Criterion Addressed by the Course

Student outcomes addressed in the course

ABET Criterion 2 is assessed through course assignments

7. Brief List of Topics Covered in Course

Gears (Spur and Helical)

Failure theory from variable loading

Shafts and shaft components

Rolling element bearings

Clutches, brakes, couplings and flywheels

II. ASSESSMENT RESULTS FOR CURRENT ASSESSMENT PERIOD

Program Outcomes Assessed in this course

Outcome 2: An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global cultural, social, environmental, and economic factor

Assessment Summary of Class Averages for Outcome: Fall 2020

Outcome 2		
Semester	Class Average (%)	Students meeting expected average (%)
Fall 2019	79.5	71.8
Spring 2020	84.1	96.6
Fall 2020	77.8	74.5
Expectation	70	70
Comment on Data	The class average and percent of students at or above average met the expectations.	

End of Semester Course Assessment Report

This summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance **(stated as %)** in each course outcome assessed in this class and the **two previous times course was assessed.**
- The acceptable class average for the class in each outcome area as set by your Department. **You cannot use any number of your choice**
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's critical **evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

5. Overall Trend over last three assessment periods

- Instructors summary of overall performance trend for each outcome measured over the last three periods.

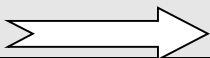
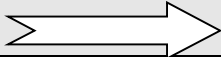
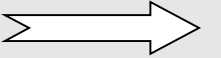
5. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer NO.

END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
MCEG 4043 MACHINE DESIGN II
FALL 2020 SEMESTER

Report Prepared by: Dr. Jaejong Park

Report Date: Dec 11, 2020

Semester	Analysis Type	Number of Students	Outcome 2 An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factor			
			Expected Class Average/	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Fall 2020	Direct	55	70	70	77.8	74.5
Spring 2020	Direct	29	70	70	84.1	96.6
Fall 2019	Direct	32	70	70	79.5	71.8
Implementation Summary	Items implemented from previous report or after meeting previous instructor	Regular meetings were scheduled to encourage students to be on track to finish the project on time.				
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them 	There was a significant grade discrepancy between groups. Communication issues have been observed in a number of groups.				
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas 	The groups can be partially chosen by the instructor based on GPA so that baseline knowledge of each group is comparable. Regular meetings with each group can be scheduled with all members present to make sure everyone is on the same page.				
Overall Trend over Periods	Ascertain if there were improvements over previous semesters 	Slight decreased class average and % students meeting expected average was observed this semester compared to previous semester. However, the numbers are still well above the expected values.				
Were Expectations Met?		Yes				

III. EXAMS

MACHINE DESIGN II FALL 2020

TITLE OF ASSIGNMENT: MIDTERM EXAM 1

TOPICS COVERED IN MIDTERM EXAM I

1. Gears – General
2. Spur and Helical Gears
3. Fatigue Failure Resulting from Variable Loading

Midterm Exam (10/14)

⚠ This is a preview of the published version of the quiz

Started: Dec 15 at 3:02pm

Quiz Instructions

This is an open book and notes exam.

Your work needs to be submitted by 10:00 AM, anything submitted after this time will get a 20% penalty. NO EXCEPTIONS.

No inappropriate internet usage (e.g., Chegg, google, etc) is allowed.

Turn on your camera and mic, make sure your hands and face are in the frame.

A trip outside the camera is not allowed.

Send me a private chat if you have any questions.

Question 1

25 pts

(25 pts) A pair of helical gears with a diametral pitch of 5 T/in and a pressure angle of 20 deg both measured on the transverse plane is used to achieve a speed reduction ratio of 4. The helix angle is 30 deg. If the center to center distance between the pinion and gear should be precisely 24 in, and the pinion is rotating at 1500 rpm by a motor rated at 5 hp, calculate the following.

- a. (6 pts) pitch diameter of each gear,
- b. (5 pts) number of teeth of each gear,
- c. (6 pts) would you expect interference from this setup and,
- d. (8 pts) torque that the gear exerts on the output shaft.

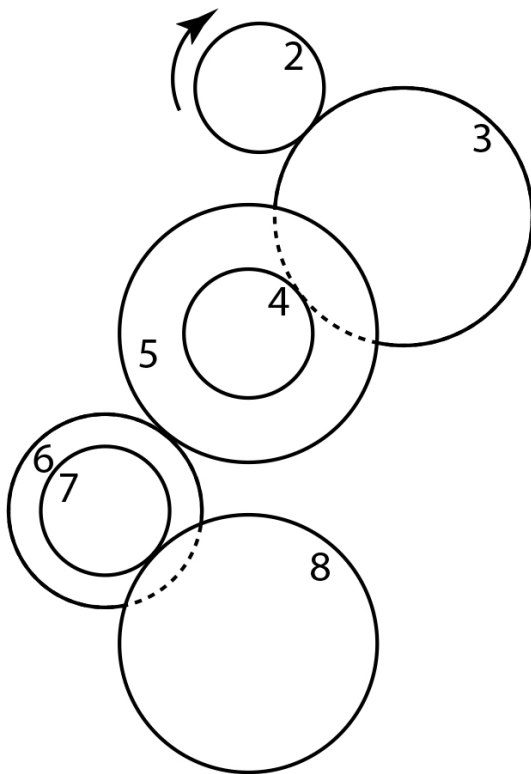
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Question 2**25 pts**

(25 pts) A gear train shown in the figure has 3 spur gears (gears 2, 3, and 8) and two compound gears (gears 4&5, and 6&7). An electric motor rated at 10 hp is driving the pinion (gear 2) at 1000 rpm. If all gears have the same diametral pitch of 3T/in and $N_2 = 25T$, $N_3 = 75T$, $N_4 = 25T$, $N_5 = 75T$, $N_6 = 50T$, $N_7 = 25T$, and $N_8 = 75T$. All gears are machined. Compute the following.

- (5 pts) What is the train value (e) for this gear train?
- (6 pts) Draw the free body diagram of gear 3. Be sure to include all components. You do not need to calculate the values.
- (7 pts) Draw the free body diagram of gear 8 and compute values for all components in the FBD.
- (7 pts) What is the face width you need for gear 7 against bending only, if you plan on fabricating it with AISI 1040 CD steel?



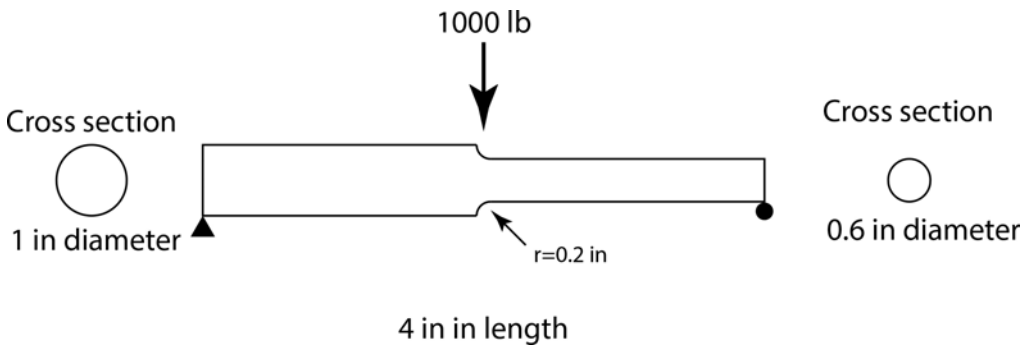
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Question 3

25 pts

(25 pts) A circular rod with a diameter of 1 in shoulder fillet with a radius of 0.2 in making the diameter to 0.6 in on the other side. The rod is rotating constantly at 250 rpm. The rod is made with a cold drawn steel whose $S_{ut} = 60 \text{ ksi}$. If this beam is subject to a load as shown, compute the following,



- (2 pts) Compute the support reaction forces.
- (3 pts) Draw shear and moment diagrams.
- (5 pts) Compute the fatigue stress concentration factor (k_f). Clearly indicate which table & figure you used to get relevant parameters.
- (5 pts) Compute the nominal stress.
- (10 pts) Compute the number of cycles to failure.

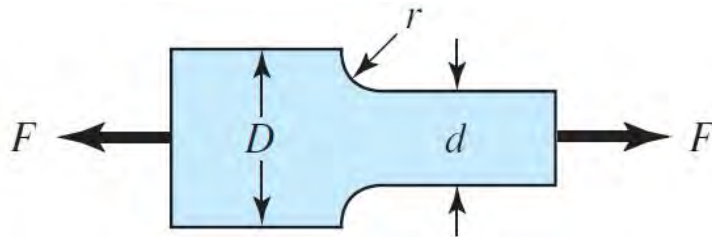
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Question 4

25 pts

(25 pts) A rectangular filleted bar shown in the figure is subject to an axial load that oscillates between -15000 and 22000 lbs. $D = 3 \text{ in}$, $r = 0.2 \text{ in}$, $d = 2.6 \text{ in}$ and the thickness of the bar is 0.25 in. If the bar is made of AISI 1040 CD steel, compute the following



- (5 pts) What is the fatigue stress concentration factor (k_f)? Clearly indicate which table & figure you used to get relevant parameters.
- (5 pts) Compute the σ_a and σ_m .
- (5 pts) Compute the equivalent completely reversed stress (σ_{rev})? Use modified Goodman criteria.
- (5 pts) What is the fully corrected endurance limit?
- (5 pts) Estimated the number of cycles to failure for this setup.

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Problem 1

speed reduction ratio = 24

a) potential combinations

n_1	n_2
1	24
2	2
3	8
4	6

$\Rightarrow$ will result in smallest gearbox

$$b) \quad n_1 = 4 = \frac{N_3}{N_2} \quad , \quad n_2 = 6 = \frac{N_5}{N_4}$$

also, for the shafts to be in line

$$N_2 + N_3 = N_4 + N_5$$

$$\Rightarrow 5N_2 = 7N_4$$

N_2 should be multiples of 7

N₄ "

5

However, N_2 & N_4 should be at least 16

to avoid any interference

$$N_4 = 16 \text{ RO} \quad N_2 = 28 \Rightarrow N_3 = 112, \quad N_5 = 120$$

$$C) \quad C = \frac{N_2 + N_3}{2P} = \frac{28 + 112}{2(2)} = \boxed{35 \text{ in}}$$

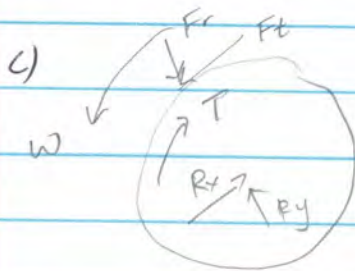
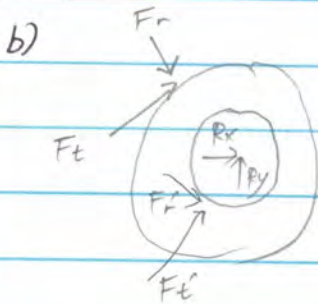
problem 2

$$a) \quad \eta_3 = \frac{N_2}{N_3} \eta_2, \quad \eta_4 = \eta_3, \quad \eta_5 = \frac{N_4}{N_5} \eta_4, \quad \eta_6 = \frac{N_5}{N_6} \eta_5$$

$$\eta_7 = \eta_6, \quad \eta_8 = \frac{N_7}{N_8} \eta_7$$

$$\eta_8 = \frac{N_2}{N_3} \frac{N_4}{N_5} \frac{N_5}{N_6} \frac{N_7}{N_8} \eta_2 = \frac{30 \cdot 30 \cdot 90 \cdot 30}{90 \cdot 90 \cdot 60 \cdot 90} \eta_2$$

$$e = 0.056$$



$$F_t = \frac{33000 \text{ hp}}{v} = \frac{33000 (10)}{\frac{\pi (90/5)^{22}}{12}} = 315.6 \text{ lb}$$

$$F_r = F_t \tan \phi \approx 115 \text{ lb}$$

↑ 20° assumption

$$R_x = 315.6 \text{ lb}$$

$$R_y = 115 \text{ lb}$$

$$T = F_t \cdot r = 2840.4 \text{ lb}$$

$$d) \quad f = \frac{K_v W_t P}{\sigma Y}$$

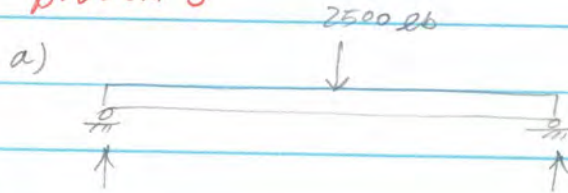
$$= 0.08 \text{ in}$$

$$K_v = \frac{1200 + v}{1200} = 1.87$$

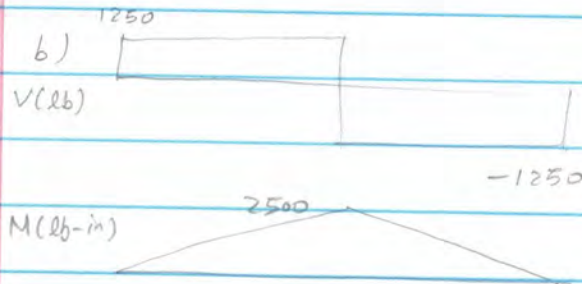
$$\sigma = 24000 \text{ psi}$$

$$Y = 0.443$$

Problem 3



due to symmetry both support reactions are 1250 lb



c) $r/d = 0.1/0.8 = 0.125$, $w/d = 1/0.8 = 1.25$

$K_t = 1.85$ ^{A-15} $\phi = 0.8$ ⁶⁻²⁰

$K_f = 1 + \phi (K_t - 1) = 1 + 0.8 (0.85) = 1.68$

d) $\sigma' = \frac{Mc}{I} = \frac{(2500 \text{ lb-in})(0.5 \text{ in})}{0.049} = 25510 \text{ psi}$

e) $\sigma_{rev} = K_f \sigma' = 1.68 \times 25510 = 42857 \text{ psi}$

$N = \left(\frac{\sigma_{rev}}{a} \right)^{1/b}$

$f = 0.9$

$S_{ut} = 65 \text{ Ksi}$

$S_e' = 32.5 \text{ Ksi}$

$n < 1$

problem 4

$$a) \quad w/d = 3.2/2.8 = 1.14, \quad r/d = 0.22/2.8 = 0.07$$

$$K_t = 2.4, \quad q = 0.8, \quad K_f = 1 + q(K_t - 1)$$

$$A-15 \quad 6-20 \quad = 2.12$$

$$b) \quad \sigma_{max} = \frac{13000}{(0.25)(2.8)} = 18,700 \text{ psi}$$

$$\sigma_{min} = \frac{-12500}{(0.25)(2.8)} = -17,860 \text{ psi}$$

$$\sigma_m = 420 \text{ psi}$$

$$\sigma_a = 18,280 \text{ psi}$$

$$c) \quad \frac{\sigma_a}{\sigma_{rev}} = \frac{\sigma_a}{1 - \frac{\sigma_m}{S_{ut}}} = \frac{18280}{1 - \frac{420}{71000}} = \boxed{18388 \text{ psi}}$$

$$d) \quad K_a = \frac{4.81}{2.7} (71)^{-0.265} = 0.875$$

$$d_e = 0.808 \sqrt{2.8 \times 0.25} = 0.676 \text{ in}$$

$$K_b = 0.879 (0.676)^{-0.107} = 0.92$$

$$K_c = 0.85$$

$$S_e = K_a K_b K_c S_e = 0.875 \times 0.92 \times 0.85 \times 30.5 = 20.87 \text{ ksi}$$

$$a = \frac{(0.9 \times 71)^2}{20.87} = 195.65 \text{ ksi}, \quad b = -\frac{1}{3} \log \left(\frac{0.9 \times 71}{20.87} \right) = -0.162$$

$$N = \left(\frac{18.39}{20.87 \times 195.65} \right)^{-\frac{1}{-0.162}} = \boxed{218 \text{ K cycles}}$$

Above Average

Midterm exam

Problem 1

Helical gear

$$P_t = 4 \text{ T/in}$$

$$\phi_t = 20$$

Speed Reduction

$$\frac{N_g}{N_p} = 3$$

$$C = 12 \text{ in}, \psi = 30$$

$$N_p = 1000 \text{ RPM}$$

$$H = 5 \text{ hp}$$

a) pitch diameter of each gear

$$\frac{d_p + d_g}{2} = 12$$

$$\frac{d_g}{d_p} = 3 \Rightarrow d_g = 3 d_p$$

$$\frac{d_p + 3 d_g}{2} = 12 \text{ in} \Rightarrow$$

$$\frac{4 d_p}{2} = 12 \text{ in}$$

$$2 d_p = 12 \text{ in}$$

$$d_p = 6 \text{ in}$$

$$d_g = 3 d_p = 6 \times 3 = 18 \text{ in}$$

b.) Number of teeth of the pinion

$$P_k = \frac{N}{d} \Rightarrow N = P_k \times d$$

$$N_p = P_k \times d_p = 4 \text{ T/in} \times 6 \text{ in} = 24 \text{ T}$$

$$N_g = P_k \times d_g = 4 \times 18 = 72 \text{ T}$$

c.) Using the interference equation

$$N_p = \frac{2k \cos \psi}{(1+2m) \sin^2 \phi_t} \times \left(m + \sqrt{m^2 + (1+2m) \sin^2 \phi_t} \right)$$

$$= \frac{2 \times 1 \times \cos 30}{(1+2 \times 3) \sin^2 20} \times \left(3 + \sqrt{3^2 + (1+2 \times 3) \sin^2 20} \right)$$

$$= 12.97 \approx 3 < 24$$

there will be no interference

d.) torque that the gear will exert on the output shaft

$$T = T_t \times r$$

$$T_t = \frac{33000 \times \text{HP}}{V}$$

$$F_t = \frac{33000 \times 5 \text{ hp}}{1570.71} = 105.04 \text{ lbf}$$

$$T_t = F_t \times \frac{d_g}{2} = \frac{105.04 \times 18}{2} = 945.36 \text{ lbf} \cdot \text{in}$$

$$n_g = \frac{4p}{3}$$

$$= \frac{1000}{3} \text{ rpm} = 333.33$$

$$V = \frac{\pi d n}{12} = \frac{\pi \times 18 \text{ in} \times 333.33}{12}$$

$$= 1570.71 \text{ ft/min}$$



Summary of Comments on Reductio

Page: 2



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Great

Author: japark

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Problem 2

$$N_2 = 25, N_3 = 75, N_4 = 25, N_5 = 75, N_6 = 50$$

$$N_7 = 25, N_8 = 75$$

machined gear

a) Train value

$$\frac{N_3}{N_2} = \frac{n_2}{n_3} \Rightarrow n_3 = \frac{N_2 n_2}{N_3}$$

$$\frac{N_4}{N_3} = \frac{n_3}{n_4} \Rightarrow n_4 = \frac{N_3 n_3}{N_4}$$

$$n_4 = n_5$$

$$\frac{N_6}{N_5} = \frac{n_5}{n_6} \Rightarrow n_6 = \frac{N_5 n_5}{N_6}$$

$$n_6 = n_7$$
$$\frac{N_8}{N_7} = \frac{n_7}{n_8} \Rightarrow n_8 = \frac{N_7 n_7}{N_8}$$

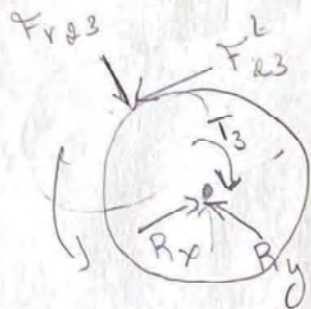
$$\rightarrow n_8 = \frac{N_7}{N_8} \times \frac{N_5}{N_6} \times \frac{N_3}{N_4} \times \frac{N_2}{N_3} n_2$$

$$n_8 = \frac{N_7}{N_8} \times \frac{N_5}{N_6} \times \frac{N_2}{N_4} \times n_2$$

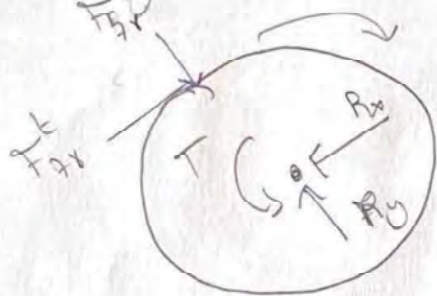
$$e = \frac{N_7}{N_8} \times \frac{N_5}{N_6} \times \frac{N_2}{N_4} = \frac{25}{75} \times \frac{75}{50} \times \frac{25}{25}$$

$$e = 0.5$$

b.) Free diagram of gear 3



c.) FBD of Gear 4



Let's determine the rpm of gear

$$n_3 = e n_2 \\ = 0.5 \times 1000 \text{ rpm} \\ = 500 \text{ rpm}$$

$$F_t = W_t = 33000 \times \frac{H}{V}$$

$$V = \frac{\bar{n} d n}{12}$$

$$d_4 = \frac{N_4}{P} =$$

$$= \frac{75}{3} = 25 \text{ in}$$

$$V_r = \frac{\bar{n} \times 25 \text{ in} \times 500 \text{ rpm}}{12 \text{ in}}$$

$$W_t = \frac{33000 \times 10}{3272.45} = 100.84 \text{ lbf}$$

Let's assume a pressure angle $\phi = 20$

$$F_P = F_t \times \tan 20 = 100.84 \text{ lbf} \times \tan 20 = 36.40 \text{ lbf}$$

$$T_r = F_t \times \frac{d}{2} = 100.84 \times \frac{25}{2} = 1260.5 \text{ lbf.in}$$

Problem 2 (Next Part)

$$+\sum F_x = 0 \Rightarrow F_t + R_x = 0 = R_x = -F_t = -100.84 \text{ lbf}$$

$$+\sum F_y = 0 = F_R + R_y = 0 = R_y = -F_R = -36.70 \text{ lbf}$$

$$T_8 - T_5 = 0 \Rightarrow T_5 = -T_8 = -1860.50 \text{ lbf} \cdot \text{in}$$

$$d.1 \quad \sigma = \frac{K_u W_t P}{F_y}$$

$$\text{Sut AISI 1040 CD} = 85$$

$$W_t = 134.45 \text{ lbf}$$

$$P = 37 \text{ lbf}$$

$$y = 0.340$$

Let's assume that our gear is made of cast iron

$$K_u = \frac{600 + V}{600} = 6$$

$$W_{t7} = W_{t8} = 100.84 \text{ lbf}$$

$$V \text{ for gear 7} = \frac{\pi d n_7}{12}$$

$$n_7 = \frac{N_5}{N_6} \times \frac{N_2}{N_4} \times n_2 = 1600 \text{ rpm}$$

$$d_7 = \frac{25}{3} = 8.33 \text{ in}$$

$$V_7 = \frac{\pi \times 8.33 \times 1600}{12} = 3271.17 \text{ ft/min}$$

$$K_u = \frac{600 + 3271.17}{600} = 6.45$$

$$\delta = \frac{K_U \times W_L \times P}{F_{xy}} \Rightarrow F = \frac{\delta \times y}{K_U \times W_L \times P} = \frac{45 \times 10^3 \times 0.3 \text{ in}}{60.45 \times 100 \times 2}$$

$$F = 14.93 \text{ in}$$



1

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 7:56:14 AM
b) force coming from gear 4 on gear 3 is missing.

Problem 3

$$d = 1 \text{ in}$$

$$r = 0.2 \text{ in}$$

$$d = 0.6$$

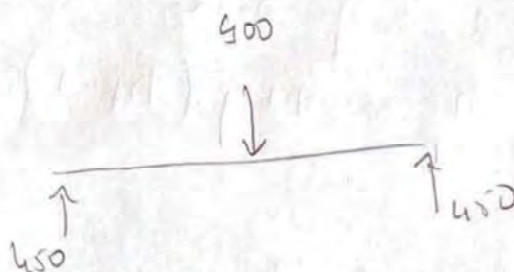
$$v_{pm} = 250 \text{ rpm}$$

CD Steel

$$S_{ut} = 65 \text{ Ks}$$

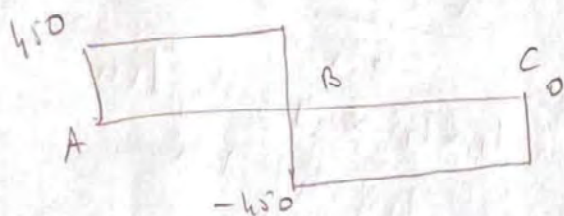
a.) Reaction Force

$$\frac{900 \text{ lb}}{2} = 450 \text{ lbf}$$

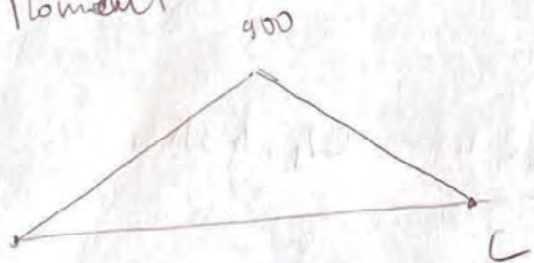


b.) Shear and moment diagrams

Shear



Moment



$$M_A = 0$$

$$M_B - M_A = 450 \times 2 = 900 \text{ lbf} \cdot \text{in}$$

$$M_B = 900 \text{ lbf} \cdot \text{in}$$

$$M_C - M_B = -450 \times 2$$

$$M_C = -900 + 900 = 0$$

c.) Fatigue stress concentration K_f from Table Figure A-18-9 and Table 6-20

$$\frac{r}{d} = \frac{0.2}{0.6} = 0.33$$

$$\frac{D}{d} = \frac{1}{0.6} = 1.66 \quad K_t = 1.35$$

From Table 6.20
 $q = 0.82$

$$K_f = 1 + q(K_t - 1) = 1 + 0.82(1.35 - 1) = 1.287$$

d.) Nominal Stress

$$\sigma_o = \frac{Mc}{I}$$

$$c = \frac{d}{2} = \frac{0.6}{2} = 0.3$$

$$I = \frac{\pi d^4}{64} = \frac{\pi \times 0.6^4}{64} = 6.36 \times 10^{-3}$$

$$\sigma_o = \frac{900 \text{ lb} \times 0.3}{6.36 \times 10^{-3}} = 42452.93 \text{ lb/in}^2 = 42.45 \text{ Ksi}$$

e.) Number of cycle to failure

$$\sigma_{rev} = K_f \times \sigma_o = 1.287 \times 42.45 = 54.63 \text{ Ksi}$$

From Figure 6.18

$$f \approx 0.5$$

$$S'_e = 0.5 \times S_{ut} = 0.5 \times 65 = 32.5 \text{ Ksi}$$

problem 3 next part

$$S_e = K_a \times K_b \times K_c \times S'_e$$

$$K_a = 2.70 \times 65^{-0.265} = 0.91 \approx 0.9$$

$$K_b = 0.479 \times 0.6^{-0.107} = 0.92$$

$$K_c = 1 \text{ since bending}$$

$$S_e = 0.9 \times 0.92 \times 32.5 = 26.611 \text{ ksi}$$

$$a = \left(\frac{f_{Sut}}{S_e} \right)^2 = \left(\frac{0.9 \times 265611}{26.611} \right)^2 = 124.6$$

$$b = -\frac{1}{3} \log \left(\frac{f_{Sut}}{S_e} \right) = -\frac{1}{3} \log \left(\frac{0.9 \times 65}{26.61} \right)$$

$$N = \left(\frac{\sigma_{rev}}{a} \right)^{1/b} = \left(\frac{54.63 \text{ ksi}}{124.6} \right)^{-1/0.11}$$

$$N = 2399.33 \text{ cycles} \approx 2400$$





Number: 1

Author: japark

Subject: Sticky Note

Date: 12/15/2020 7:56:33 AM

all necessary steps are well laid out.

Problem 4

1.) Fatigue Stress Factor From Figure A-15-5

$$\frac{r}{d} = \frac{0.2}{2.6} = 0.077$$

$$\frac{b}{d} = \frac{3}{2.6} = 1.15$$

$$K_t = 1.9$$

Using Figure
Table 6-20

$$S_{ut} = 76 \text{ Ksi}$$

$$r = 0.2$$

$$q = 0.6$$

$$K_f = 1 + q(K_t - 1) = 1 + 0.6(1.9 - 1) = 1.54$$

b.) Compute σ_a and σ_m

$$\sigma = \frac{F}{A}$$

$$A = dt = 2.6 \times 0.25 = 0.65 \text{ in}^2$$

$$\sigma_{max} = \frac{20000}{0.65} = 30.76 \text{ Ksi}$$

$$\sigma_{min} = \frac{-125000}{0.65} = -19.23 \text{ Ksi}$$

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2} = \frac{30.76 - 19.23}{2} = 5.765 \text{ Ksi}$$

$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2} = \frac{30.76 + 19.23}{2} = 24.995 \text{ Ksi}$$

$$\sigma_m = 5.765 \times K_f = 8.87 \text{ Ksi}$$

$$\sigma_a = 24.995 \times K_f = 38.49 \text{ Ksi}$$

c.) Equivalent completely reversed

$$\frac{\sigma_a}{\sigma_{rev}} + \frac{\sigma_m}{\sigma_{ut}} = 1$$

$$\frac{\sigma_a}{\sigma_{rev}} = 1 - \frac{\sigma_m}{\sigma_{ut}}$$

$$\sigma_{rev} = \frac{\sigma_a}{1 - \frac{\sigma_m}{\sigma_{ut}}} = \frac{38.49}{1 - \frac{8.87}{76}}$$

$$\sigma_{rev} = 43.57 \text{ Ksi}$$

d.) Fully corrected endurance limit

$$S'_e = 0.5 \times \sigma_{ut} = 0.5 \times 76 = 38 \text{ Ksi}$$

$$K_a = 2.70 \times 76^{-0.200} = 0.96$$

$$K_b = 0.91 \times 2.6^{-0.157} = 0.78$$

$$K_c = 0.45$$

$$S_e = 0.96 \times 0.78 \times 0.45 \times 30 = 21.67 \text{ ksi}$$

e) Number of cycle

From Figure 6-18

$$f = 0.98$$

$$a = \frac{(f S_{ut})^2}{S_e} = \frac{0.98 \times 76}{21.67} = 206.41$$

$$b = -\frac{1}{3} \log \left(\frac{f S_{ut}}{S_e} \right) = -\frac{1}{3} \log \left(\frac{0.98 \times 76}{21.67} \right) = -0.16$$

$$N = \left(\frac{S_{rev}}{a} \right)^{1/b} = \left(\frac{43.57}{206.41} \right)^{-1/0.16} = 16678.033 \text{ cycles}$$



 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 7:56:44 AM
all necessary steps are well laid out.

Average

9:50 am

Crystal Griggs Exam 1

- ① Given: helical gears, $P = 5 \text{ T/in}$, $\phi = 20^\circ$, $m = 5$ (red), $\psi = 30^\circ$, $C = 16 \text{ in}$
 $n_p = 1250 \text{ rpm}$, $H = 5 \text{ hp}$. a) P_g ? b) N_g c) interference? d) torque gear on output shaft

a) $P_g = N/d$

b) $N_g = \frac{N_p^2 \sin^2 \phi - 4K^2}{4K^2 - 2N_p \sin^2 \phi} =$

$N_p = \frac{2K}{(1+2m) \sin^2 \phi} (m + \sqrt{m^2 (1+2m) \sin^2 \phi})$, $m = 5$, $K = 1$, $\phi = 20^\circ \rightarrow N_p =$

c) no interference

d) $T = F \cos \phi \times r = \cos 20^\circ \times$

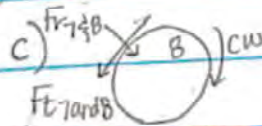
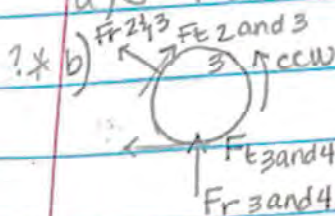
$d = N_g \cdot m = \times 5 =$



1

- ② Given: 3 spur gears (2, 3 & 8) and 2 compound gear (4 & 5, 6 & 7). $H = 10 \text{ hp}$
 $n_{p2} = 1000 \text{ rpm}$, $P = 3 \text{ T/in}$, $N_2 = 25 \text{ T}$, $N_3 = 75 \text{ T}$, $N_4 = 25 \text{ T}$, $N_5 = 75 \text{ T}$,
 $N_6 = 50 \text{ T}$, $N_7 = 25 \text{ T}$, $N_8 = 75 \text{ T}$. All gears machined. a) train value
 b) FBD of gear 3 c) FBD of gear 8 & compute all values, d) Face width for gear 7 w/ AISI 1040 CD steel?

a) $e = \frac{N_2}{N_3} \frac{N_3}{N_4} \frac{N_5}{N_6} \frac{N_7}{N_8} = \frac{25 \text{ T}}{75 \text{ T}} \frac{75 \text{ T}}{25 \text{ T}} \frac{75 \text{ T}}{50 \text{ T}} \frac{25 \text{ T}}{75 \text{ T}} = \frac{25 \text{ T}}{50 \text{ T}} = \frac{1}{2} = 0.5$



d) $\sigma = \frac{K_v W_t}{F_m y} =$



2

Summary of Comments on CamScanner 10-14-2020

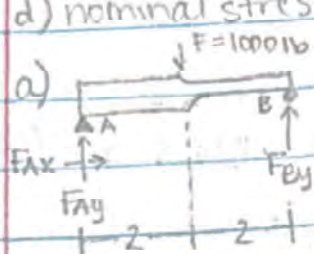
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Page: 1

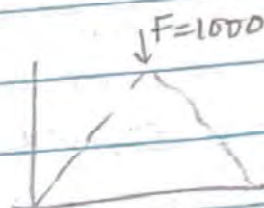
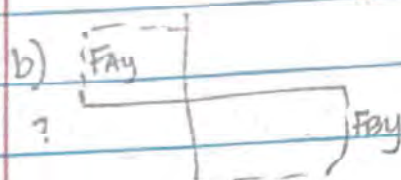
 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 8:00:34 AM
a) $r_p + r_g = 16$, $r_g/r_p = 5$, you can compute the pitch radii, then use P to compute the N.

 Number: 2 Author: japark Subject: Sticky Note Date: 12/15/2020 8:00:45 AM
both FBDs are missing shaft forces, c) is missing torque.
d) this equation is for SI units.

- ③ Given: circular rod, $D=1$ in, $r=0.2$ in, $d=0.6$ in, $n=250$ rpm, cold drawn steel, $S_{ut}=65$ KSI. a) reaction forces, b) draw shear & moment diagrams, c) K_f w/ table & figure d) nominal stress (σ_o), e) number of cycles to failure (N)



$$\sum M_A = 0 \rightarrow (1000 \cdot 2) + ($$



c) $K_f = 1 + q(K_t - 1) = 1 + 0.814(1.8 - 1) = 1.6512$

$$q = \frac{1}{1 + \sqrt{r}/r} = \frac{1}{1 + 0.102/\sqrt{0.2}} = 0.814$$

bending: $\bar{r}_a = 0.246 - 3.08(10^{-3})S_{ut} + 1.51(10^{-5})S_{ut}^2 - 2.67(10^{-8})S_{ut}^3$

$$\bar{r}_a = 0.246 - 3.08(10^{-3})(65) + 1.51(10^{-5})(65)^2 - 2.67(10^{-8})(65)^3 = 0.102$$

(table A-15-5): $\frac{r}{d} = \frac{0.2}{0.6} = 0.33$, $\frac{D}{d} = \frac{1}{0.6} = 1.67 \rightarrow K_t = 1.8$

d) $\sigma_o = \frac{32M}{\pi d^3} = \frac{32(1000)}{\pi(0.6)^3} = 47157.02 \text{ psi} = 47.157 \text{ KSI}$

e) $S_e = (0.5)S_{ut} = (0.5)65 = 32.5 \text{ KSI}$

(table 6-2): $a = 2.70$, $b = -0.265 \rightarrow K_a = aS_{ut}^b = 2.7(65)^{-0.265} = 0.89$

$$K_b = \left(\frac{d}{0.3}\right)^{-0.107} = \left(\frac{0.6}{0.3}\right)^{-0.107} = 0.93, \text{ bending: } K_c = 1$$

*? rotating rod: $K_d = \frac{S_T}{S_{RT}} =$

* $S_e' = (K_a)(K_b)(K_c)(K_d)(S_e) = (0.89)(0.93)(1)(\quad)(32.5) =$

$$N = \left(\frac{\sigma_{rev}}{a}\right)^{1/b} =$$

$$a = \frac{(fS_{ut})^2}{S_e}; f = , a =$$

$$b = -\frac{1}{3} \log\left(\frac{fS_{ut}}{S_e}\right) =$$

$$\sigma_{rev} = \sigma_o \times K_f = 47.157 \times$$



 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 8:01:01 AM
e) kd could be assumed to be 1.

④ Given: circular bar, axial load, $F_{min} = -12500$, $F_{max} = 20000$ lbs,

$D = 3$ in, $r = 0.2$ in, $d = 2.6$ in, $t = 0.25$ in, AISI 1030 CD steel

a) KF w/ table 3-fig. b) σ_a & σ_m , c) modified Goodman σ_{rev} d) endurance limit
e) number of cycles?

$$a) K_f = 1 + q(K_t - 1) = 1 + 0.85(1.9 - 1) = 1.765$$

(fig 6-20): $q = 0.85$, (table A-15-5): $\frac{r}{d} = \frac{0.2}{2.6} = 0.08$, $\frac{D}{d} = \frac{3}{2.6} = 1.15$, $K_t = 1.9$

$$b) \sigma_a = \left| \frac{\sigma_{max} - \sigma_{min}}{2} \right| (K_f) = \left| \frac{30.77 - (-19.23)}{2} \right| (1.765) = 44.125 \text{ ksi}$$

$$\sigma_{max} = \frac{F_{max}}{A} = \frac{20000}{(d)(t)} = \frac{20000}{(2.6)(0.25)} = 30769.23 \text{ psi} = 30.77 \text{ ksi}$$

$$\sigma_{min} = \frac{F_{min}}{A} = \frac{-12500}{(2.6)(0.25)} = -19230.77 \text{ psi} = -19.23 \text{ ksi}$$

$$\sigma_m = \left(\frac{\sigma_{max} + \sigma_{min}}{2} \right) (K_f) = \left(\frac{30.77 + (-19.23)}{2} \right) (1.765) = 10.184 \text{ ksi}$$

$$c) \sigma_{rev} = \frac{\sigma_a}{1 - (\sigma_m / S_{ut})} = \frac{44.125}{1 - (10.184 / 65)} = 52.323 \text{ ksi}$$

$$d) S_e = (0.5) S_{ut} = (0.5) 65 = 32.5$$

$$\text{(table 6-2): } a = 2.70 \quad b = -0.265 \rightarrow K_a = a S_{ut}^b = 2.7(65)^{-0.265} = 0.88$$

axial load: $K_b = 1$, axial: $K_c = 0.85 \rightarrow S_e' = (K_a)(K_b)(K_c)(S_e)$

$$S_e' = (0.88)(1)(0.85)(32.5) = 24.31 \text{ ksi}$$

$$e) N = \left(\frac{\sigma_{rev}}{a} \right)^{1/b} = \left(\frac{52.323}{140.78} \right)^{1/-0.127} = 2424.56 \text{ cycles}$$

$$a = \frac{(f S_{ut})^2}{S_e}, \quad f = 0.9; S_{ut} < 490; a = \frac{(0.9 \times 65)^2}{24.31} = 140.78$$

$$b = -\frac{1}{3} \log \left(\frac{f S_{ut}}{S_e} \right) = -\frac{1}{3} \log \left(\frac{0.9 \times 65}{24.31} \right) = -0.127$$



 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 8:01:08 AM
Great. Only thing is the stress should be multiplied with the kf.

 Author: japark Subject: Sticky Note Date: 12/15/2020 8:04:58 AM
67/100

Below Average

Machine II Midterm

Don Brackford

1.) Helical gear:

$$P = 5 \text{ T/in}$$

$$\phi = 20^\circ$$

$$m = 1/5$$

$$\psi = 30^\circ$$

$$n = 1250 \text{ rpm}$$

$$W = 5 \text{ hp}$$

$$C = 16 \text{ in}$$

$$p = \pi/p = \pi/5 = 0.63 \text{ in}$$

$$p = \pi m$$

$$C = \frac{d_p + d_g}{2}$$

$$16 = \frac{6.4 + d_g}{2} \quad (d_g = 25.6 \text{ in})$$

Q.

$$16/5 = 3.2 = r_p$$

$$(d_p = 6.4 \text{ in})$$

$$N_p = 6.4 \cdot 5 = 32 \text{ T}$$

$$N_g = 25.6 \cdot 5 = 128 \text{ T} \quad 5.$$

C.) Use interference equations

$$b.) T = \frac{1}{2} W_t \Rightarrow T_g = (25.6/2) \cdot 528 = (6758.4 \text{ lbf} \cdot \text{in})$$

$$W_t = 33000 \left(\frac{10}{1250} \right) = 528 \text{ lbf}$$



Summary of Comments on Midterm Machine II Don Bradford.pdf

Page: 1



Number: 1

Author: japark

Subject: Sticky Note

Date: 12/15/2020 8:03:19 AM

16" is the $r_p + r_g$. I do not see how you get $1250/2$ as pitch line velocity.

2.) $N_2=20$ $N_3=60$, $N_4=20$, $N_5=60$, $N_6=40$, $N_7=20$, $N_8=60$

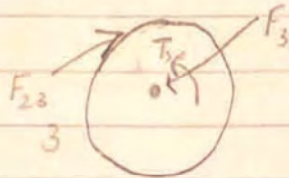
a.)

$$n_8 = \frac{N_2}{N_3} \cdot \frac{N_3}{N_4} \cdot \frac{N_5}{N_6} \cdot \frac{N_7}{N_8} \cdot n_2$$

$$n_8 = \frac{20}{30} \cdot \frac{30}{20} \cdot \frac{60}{40} \cdot \frac{20}{60} \cdot 500 = 250$$

$$250/500 = \boxed{0.5}$$

b.) FBD₃:



c.) FBD₈:

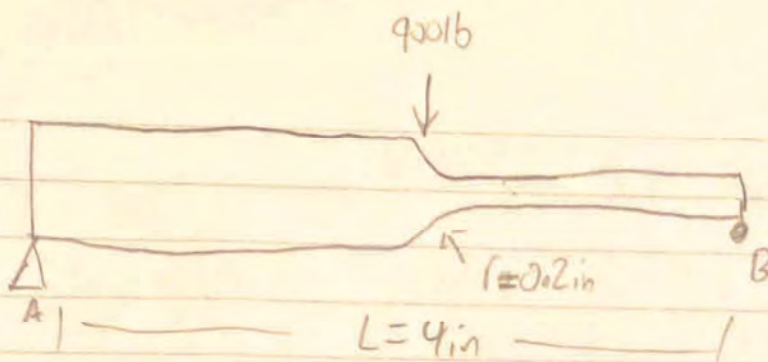
$$P = 2 \text{ T/in}$$

$$W = 10 \text{ hp}$$



$$d_8 = \frac{N_3}{P} = \frac{60}{2} = 30$$

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 8:03:28 AM
b) force coming from gear 4 is missing.



a.)

$$\sum F_x = 0$$

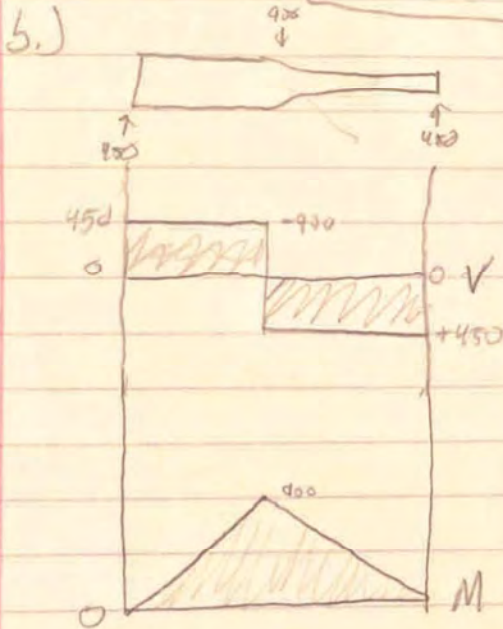
$$\sum F_y = 0$$

$$A + B - 900 = 0$$

$$\sum M_A = 0$$

$$-900 \cdot 2 + 4B = 0$$

$$-1800 = -4B \quad (B = 450 \text{ lb} \Rightarrow A = 450 \text{ lb})$$



c.) $K_f = 1 + q(K_t - 1)$

$$r/b = 0.2/0.6 = 0.3$$

$$D/b = 1/0.6 = 1.67$$

$$q = 0.61 \text{ from Fig 6-21 (P 304)}$$

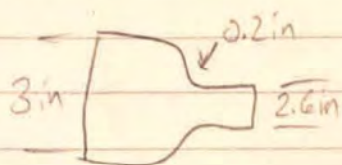
$$K_t = 1.4 \text{ from Fig A-15-9 (P 1036)}$$

$$K_f = 1 + 0.61(1.4 - 1) = 1.244$$



 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 8:03:50 AM
part d, and e are missing.

4.)



1030 CD $S_{ut} = 76 \text{ ksi (A-20)}$

$$3/2.6 = 1.15 = D/d$$

$$r/d = 0.2/2.6 = 0.077$$

a.) $K_f = 1 + q(K_t + 1)$

$q = 0.7$ (Fig 6-21)

$K_t = 1.8$ (Fig A-15-7)

$$K_f = 1 + 0.7(1.8 - 1) = 1.56$$



b.) find σ_a & σ_m

$$\sigma_a = K_f \sigma_{ao} \quad \sigma_{max} = \frac{20000}{(2.6)(0.25)} = 30769.2$$

$$\sigma_m = K_f \sigma_{mo} \quad \sigma_{min} = \frac{-12500}{(2.6)(0.25)} = -19230.8$$

$$\sigma_m = \frac{30769.2 - 19230.8}{2} = 5769.2 \cdot 1.56 = 9000 \text{ ksi}$$

$$\sigma_a = \left| \frac{\sigma_{min} - \sigma_{max}}{2} \right| = 25000 \cdot 1.56 = 39000 \text{ ksi}$$

$$c. \sigma_{rev} = \frac{\sigma_a}{1 - \frac{\sigma_m}{S_{ut}}} = \frac{39000}{1 - \frac{9000}{76}} = -332.14 \text{ ksi}$$

d.) $S_e = K_a K_b K_c \dots (S_e')$

e.) $N = \left(\frac{\sigma_r}{\sigma_a} \right)^{1/6}$

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 8:04:02 AM
The unit for sigma a and m should be psi.

55/100

MACHINE DESIGN II

FALL 2020

TITLE OF ASSIGNMENT: FINAL EXAM

TOPICS COVERED IN FINAL EXAM

1. Shafts and Shafts Components
2. Rolling Contact Bearings
3. Brakes
 - a. Internal expanding brake
 - b. External contracting brake
 - c. Band brake

Final exam (12/7)

! This is a preview of the published version of the quiz

Started: Dec 7 at 7:20am

Quiz Instructions

This is an open book and notes exam. The exam will be available at 7:35 AM.

Your work needs to be submitted by 9:30 AM. Anything **submitted after this time will get a 20% penalty. NO EXCEPTIONS.**

Make assumptions if deemed necessary. Clearly state what and why you are making any assumptions.

No inappropriate internet usage (e.g., Chegg, Google, etc.) is allowed.

Turn on your camera and mic, make sure your hands and face are in the frame.

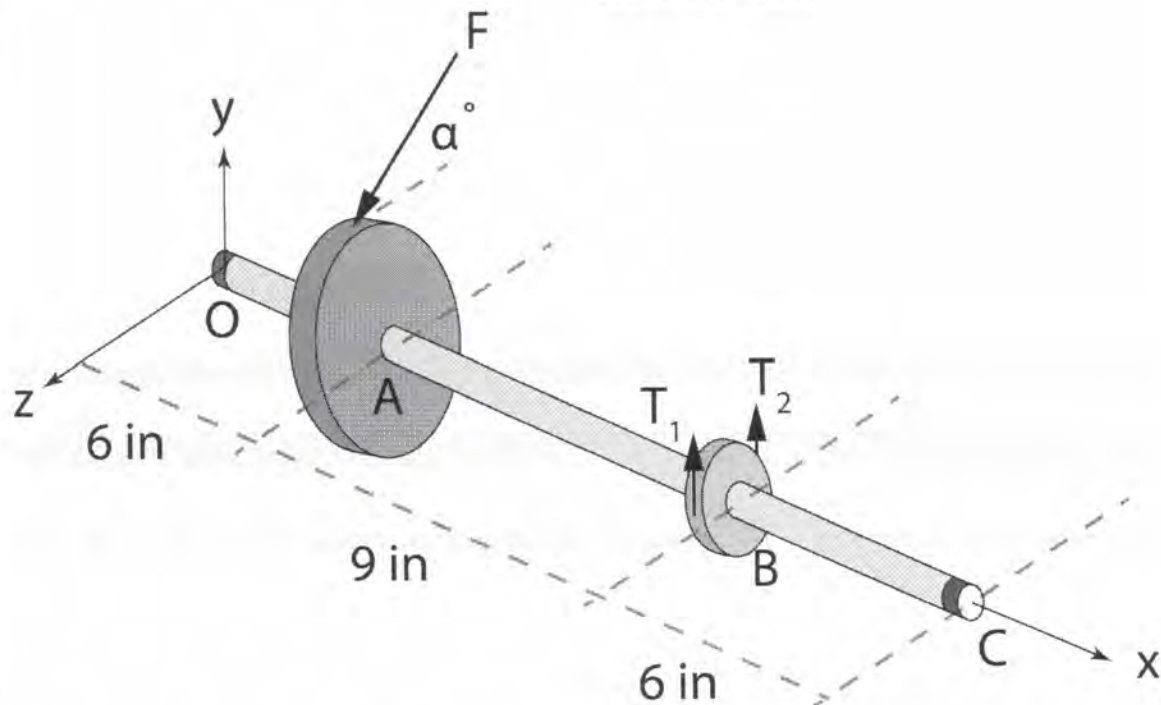
A trip outside the camera is not allowed.

Send me a zoom private chat if you have any questions.

Question 1

35 pts

(35 pts) A shaft in the figure is rotating at 2500 rpm, driven by a spur gear at A which receives 800 lb of total force (F) from a motor driving it. This spur gear has a 25° pressure angle and has 10 in pitch diameter. The power from this gear travels through the section of the shaft then drives the pulley at B. This pulley is 4 in in diameter and experiences two tensions (T_1 and T_2) where the tight side has 3 times larger tension than the loose side. Typical ball bearings are used at O and C to support the shaft. The bearings are mounted against a sharp shoulder fillet and the gear and the pulley are assembled onto the shaft via a square key using endmill keyseats. The shaft diameter is 1.5 in and made of AISI 1040 HR steel. Answer the following subproblems.



- (5 pts) What are the values of tensions (T_1 and T_2) at the pulley.
- (5 pts) Draw necessary free body diagrams and find the corresponding support reactions.
- (5pts) Draw shear and moment diagrams using the information you obtained.
- (5pts) Indicate the critical location and compute the total moment and torque values.
- (5pts) Using the Gerber fatigue criteria, set up the equation to find the factor of safety. You do not need to solve for the factor of safety but provide values for all parameters.
- (5pts) Is the first cycle yielding expected in the shaft? (hint: maximum stress can be computed using von-mises formulation)
- (5pts) Compute the load ratings (C_{10}) for both bearings if 12,000 hour life is required.

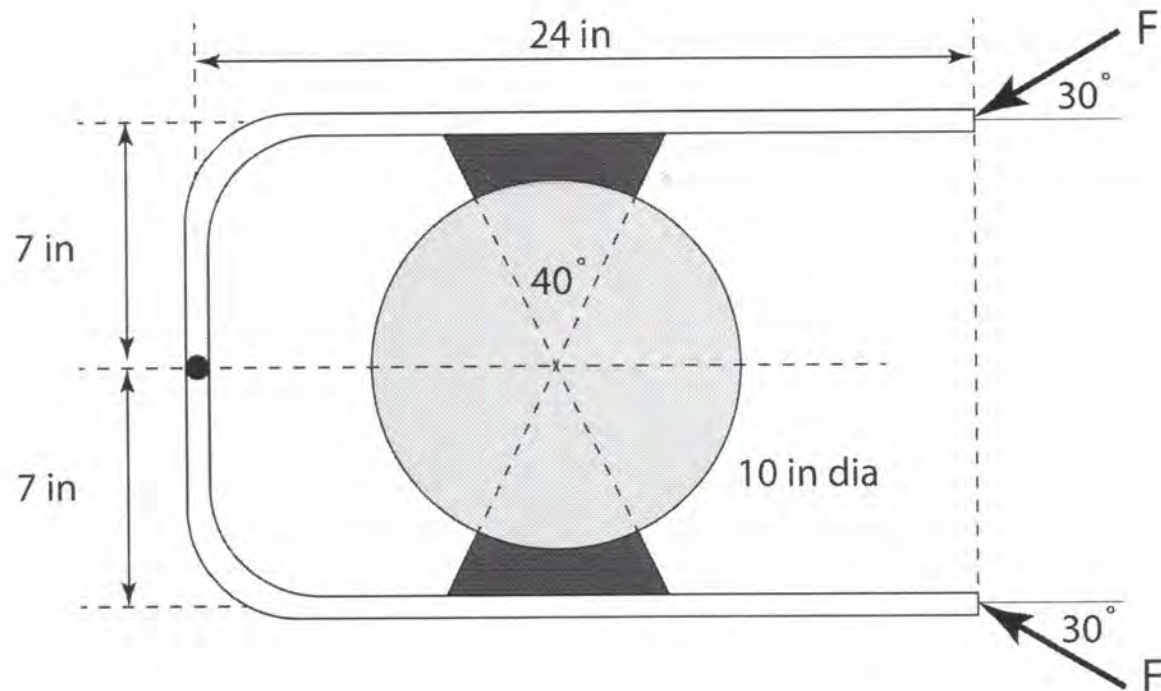
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Question 2

35 pts

(35 pts) A pair of external contracting shoe mechanisms are used to control the rotational speed of a circular drum as shown in the figure. The drum is rotating **counterclockwise**. The width of the brake (b) is 0.5in and the friction coefficient is 0.25.



- (5pts) Draw the FBD of each shoe mechanism separately and indicate which side is the self-energizing.
- (5pts) Compute all relevant angles (i.e., θ_1 , θ_2 , and θ_a) for the self-energizing shoe.
- (5pts) Write the complete moment balance equation for the self-energizing shoe. Be sure to include the values of moment arm lengths for actuation force(s).
- (10pts) Find the maximum possible actuation force F for the self-energizing shoe if the maximum pressure that the shoe material can handle is 12 kpsi.
- (5pts) Find the maximum pressure that happens at the non-self-energizing shoe.
- (5pts) Compute the total system braking torque.

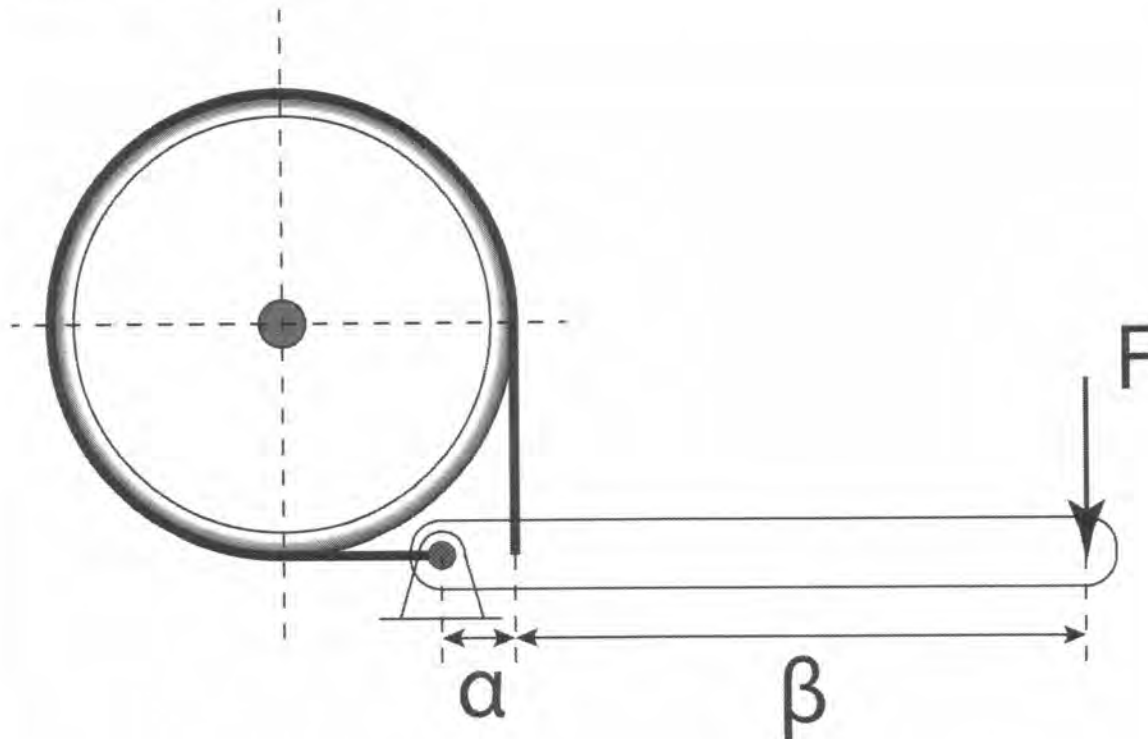
Upload

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Question 3

30 pts

(30pts) A band brake is proposed to control the angular speed of a drum (diameter=7in) as shown in the figure. $\alpha = 2 \text{ in}$, $\beta = 8 \text{ in}$, the band has a friction coefficient of 0.2, its face width is 1 in, F is 200 lb. If the drum is rotating **clockwise**, compute the following



- (5 pts) Identify the side that will experience higher tension (tight side).
- (5 pts) Draw the FBD of the lever, be sure to include all the forces.
- (10 pts) Compute the tensions on both sides.
- (10 pts) Compute the tensions on both sides if the drum is rotating in the other direction.

Upload

Choose a File

Quiz saved at 7:20am

Submit Quiz

Problem 1

a) $F_t = 800 \cos 25^\circ = 725 \text{ lb}$

$F_r = 800 \sin 25^\circ = 338 \text{ lb}$

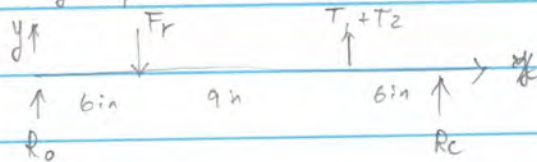
$\sqrt{+\Sigma T_x = 0} ; (725 \text{ lb})(5 \text{ in}) + (-F_p \times 2 \text{ in}) = 0$

$F_p = 1812.5 \text{ lb} = (T_1 - T_2) \quad , \quad T_1 = 3T_2$

$2T_2 = 1812.5 \text{ lb} \quad T_2 = 906.25 \text{ lb}$

$T_1 = 2718.75 \text{ lb}$

b) xy plane



$\Rightarrow \sqrt{+\Sigma M_o = 0} ; -F_r(6 \text{ in}) + (T_1 + T_2)(15 \text{ in})$

$+ R_c(21 \text{ in}) = 0$

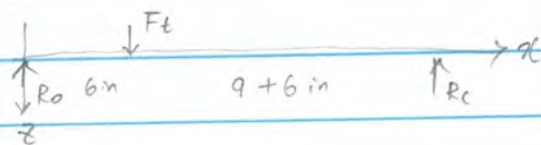
$R_c = -2492.71 \text{ lb}$

$\Rightarrow \sqrt{+\Sigma F_y = 0} ; R_o - F_r + T_1 + T_2 + R_c = 0$

$R_o = 338 - 2718.75 - 906.25 - (-2492.71) = 0$

$R_o = -794.29 \text{ lb}$

xz plane



$\Rightarrow \sqrt{+\Sigma M_o = 0} ; -F_t(6 \text{ in}) + R_c(21 \text{ in}) = 0$

$R_c = +207 \text{ lb}$

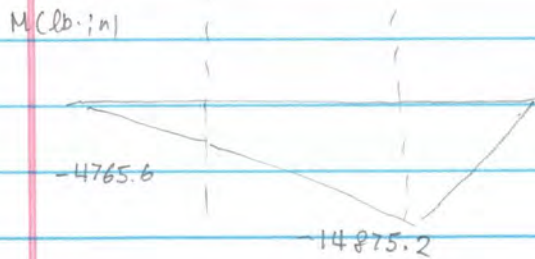
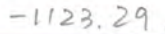
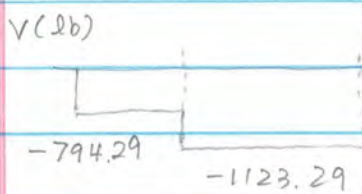
$\Rightarrow \sqrt{+\Sigma F_z = 0} ; R_o - F_t + R_c = 0$

$R_o = 518 \text{ lb}$

c)

c) xy plane 2492.71

xz plane



d) $M = 14927 \text{ lb-in}$, $T = 3625 \text{ lb-in}$ @ B
 $\parallel$ $\parallel$
 M_a T_m

e)

$$A = \sqrt{4(K_f M_a)^2 + 3(K_{fs} T_a)^2}, \quad B = \sqrt{4(K_g M_m)^2 + 3(K_{gs} T_m)^2}$$

$$\frac{1}{n} = \frac{8A}{\pi d^3 S_e} \left\{ 1 + \left[1 + \left(\frac{2BS_e}{AS_{ut}} \right)^2 \right]^{1/2} \right\}$$

$$K_a = 14.4 (76) \quad -0.718 = 0.643$$

$$K_b = 0.879 (1.5)^{-0.107} = 0.842$$

$$K_c = 1$$

$$S_e = 0.643 \times 0.842 \times 1 \times \frac{76}{2}$$

$$= 20.57 \text{ KSI}$$

von-mises stress

$$f) \sigma'_{max} = \left[\left(\frac{32 K_f (M_m + Ma)}{\pi d^3} \right)^2 + 3 \left(\frac{16 K_{fs} (T_m + Ta)}{\pi d^3} \right)^2 \right]^{1/2}$$

$$= \sqrt{\left(\frac{32 (2.14) (14927)}{\pi (1.5)^3} \right)^2 + \left(\frac{16 (3) (3625)}{\pi (1.5)^3} \right)^2}$$

$$= \sqrt{96408^2 + 16410.6^2} = 97794.6 \text{ psi}$$

$$n_y = \frac{S_y}{\sigma'_{max}} = \frac{97.8 \text{ ksi}}{97794.6} < 1 \quad \text{so yield expected}$$

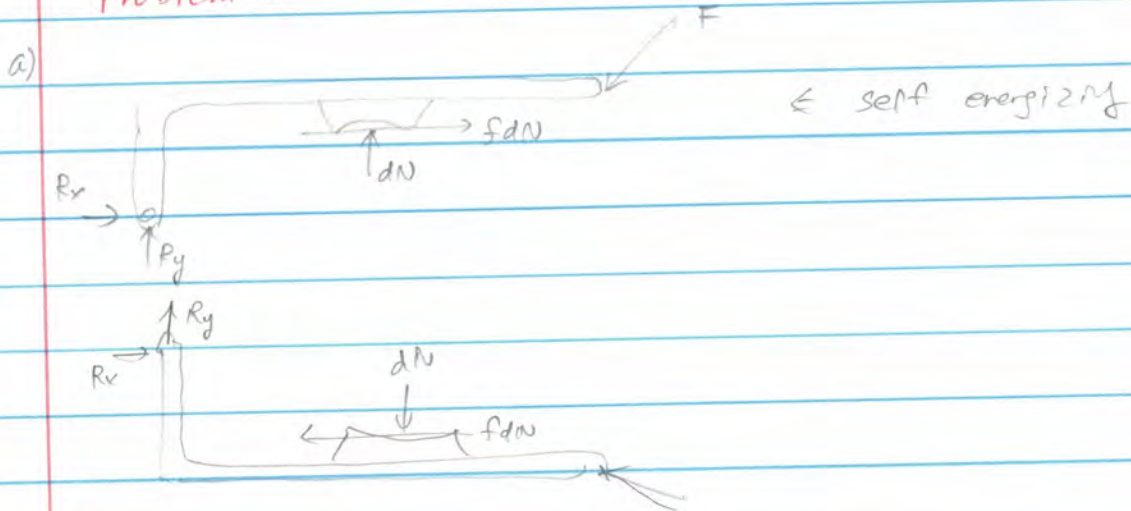
$$g) C_{10@0} = 948 \left(\frac{12000 \cdot 2500 \cdot 60}{10^6} \right)^{1/3} \quad ; \quad F_{D@0} = \sqrt{794.29^2 + 518^2} = 948 \text{ lb}$$

$$= 11532 \text{ lb}$$

$$C_{10@c} = 30423 \text{ lb}$$

$$F_{D@c} = \sqrt{2492.71^2 + 207^2} = 2501 \text{ lb}$$

Problem 2



b) $\theta_1 = 70^\circ$, $\theta_2 = 110^\circ$, $\theta_a = 90^\circ$

$\nearrow 6.06 F$

$\nearrow 12 F$

c) $\sum M_{\text{Hinge}} = 0$; $M_N - M_f + F \cos 30^\circ (7 \text{ in}) - F \sin 30^\circ (24 \text{ in}) = 0$

d) $M_N = \frac{P_a b r a}{\sin \theta_a} \int_{\theta_1}^{\theta_2} \sin^2 \theta d\theta = \frac{(12 \times 10^3)(0.5)(5)(10)}{1} \int_{70^\circ}^{110^\circ} \sin^2 \theta d\theta$

$= 1.1523 \times 10^7 \text{ lb-in}$

$M_f = \frac{f P_a b r a}{\sin \theta_a} \int_{\theta_1}^{\theta_2} \sin \theta (r - a \cos \theta) d\theta = \frac{(0.25)(12 \times 10^3)(0.5)(15)}{1} \int_{\theta_1}^{\theta_2} \sin \theta (5 - 10 \cos \theta) d\theta$

$= 0.25 \times (12 \times 10^3) \times 0.5 \times 5 \times 196$

$= 1.47 \times 10^6 \text{ lb-in}$

$1.1523 \times 10^7 - 1.47 \times 10^6 = 5.94 F$

$F = 1.7 \times 10^6 \text{ lb}$

$$e) \quad \checkmark + \sum M_{Hinge} = 0 ; \quad - M_N - M_f - F \cos 30^\circ (7 \text{ in}) + F \sin 30^\circ (24 \text{ in}) = 0$$

$$- 960 \text{ Pa} - 196 \text{ Pa} + 5.94 F = 0$$

$\uparrow 1.7 \times 10^6$

$$P_a = 8.74 \text{ Kip}$$

$$f) \quad T_{up} = \frac{0.25 (12 \times 10^3) (0.5) (5)^2 (\cos 70^\circ - \cos 110^\circ)}{\sin \theta_a}$$

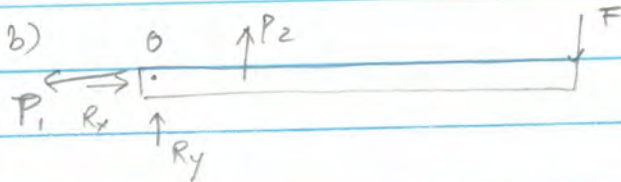
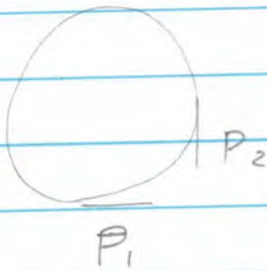
$$= 25651.5 \text{ lb-in}$$

$$T_{down} = 18683 \text{ lb-in}$$

$$T_{total} = 44334.4 \text{ lb-in}$$

Problem 3

a)



c) $\sum M_O = 0$; $R_2(2\text{in}) - F(10\text{in}) = 0$; $R_2 = 1000 \text{ lb}$

$$\frac{P_1}{P_2} = e^{f\phi} \quad \phi = 270^\circ = \frac{3\pi}{2}, \quad f = 0.2$$

$$P_1 = P_2 e^{(0.2)(\frac{3\pi}{2})} = 2566.33 \text{ lb}$$

d) $\frac{P_1}{P_2} = e^{f\phi} \quad \Leftarrow P_1 = 1000 \text{ lb}$

$$P_2 = \frac{1000}{e^{(0.2)(\frac{3\pi}{2})}} = P_2 = 390 \text{ lb}$$

Above Average

MCEG 4043 - Final Exam① Given

$$n = 2000 \text{ rpm}$$

$$F = 1000 \text{ lb}$$

$$\alpha^\circ = 20^\circ$$

$$d = 10 \text{ in}$$

tight tension = 4 loose tension

ball bearings @ O & C

endmill key seats

$$d_{\text{shaft}} = 1.5 \text{ in}$$

AISI 1040 CD steel

$$d_B = 4 \text{ in}$$

Solution(a) values T_1 & T_2

$$\text{Torque} = F_t \times r$$

$$= 1000 \times 5 \text{ in}$$

$$T = 5000 \text{ lb}\cdot\text{in}$$

$$\text{Torque @ B} = 5000 \text{ lb}\cdot\text{in}$$

$$T_1 > T_2$$

$$T_1 = 4 T_2$$

$$5000 \text{ lb}\cdot\text{in}$$

$$= (T_1 - T_2) \times 2$$

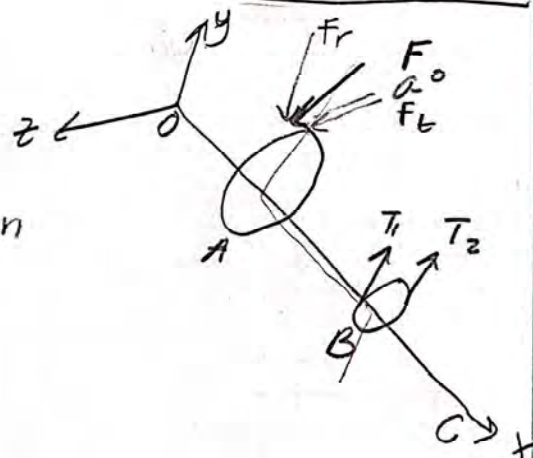
$$5000 \text{ lb}\cdot\text{in} = (4T_2 - T_2) \times 2$$

$$5000 \text{ lb}\cdot\text{in} = 3T_2 \times 2$$

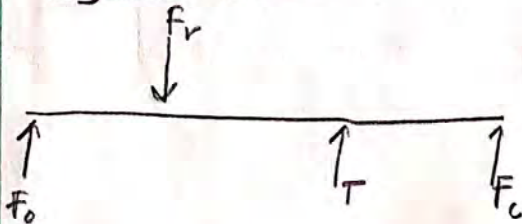
$$\boxed{833.33 \text{ lb} = T_2}$$

$$T_1 = 4 T_2$$

$$\boxed{T_1 = 3333.33 \text{ lb}}$$

Schematic

(b) FBD

xy analysis:

$$F_r = F_t \tan(20^\circ)$$

$$= 1000 \tan(20^\circ)$$

$$F_r = 364 \text{ lb}$$

$$T = T_1 + T_2 = 4166.66 \text{ lb}$$

$$\sum M_O = 0$$

$$-F_r \times 6 + T \times 15 + F_c \times 21 = 0$$

$$F_c = -2872.2 \text{ lb}$$

$$\sum F_y = 0$$

$$F_0 - F_r + T + F_c = 0$$

$$F_0 = 948.5 \text{ lb}$$

Summary of Comments on Louis-MCEG 4043 Final Exam

Page: 1



Number: 1

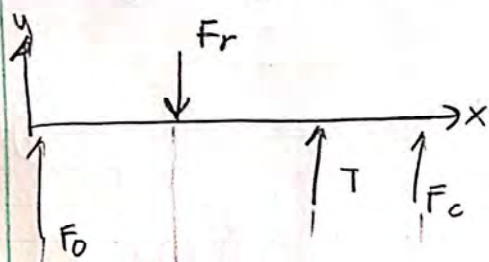
Author: japark

Subject: Sticky Note

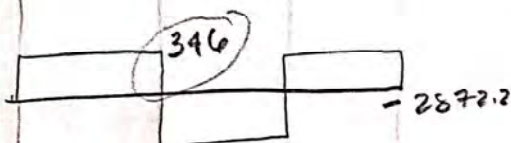
Date: 12/15/2020 10:21:55 AM

Only the transmitted load contribute to the torque. A minor mistake.

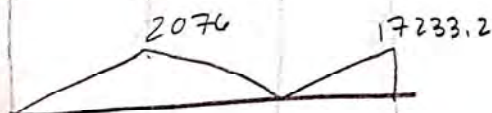
c) XY analysis



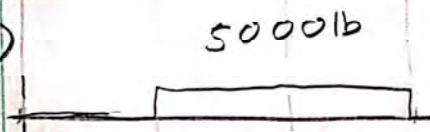
V(lb)



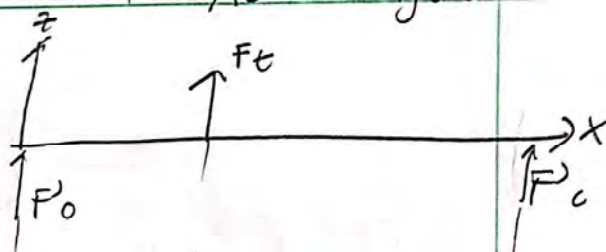
M(lb·in)



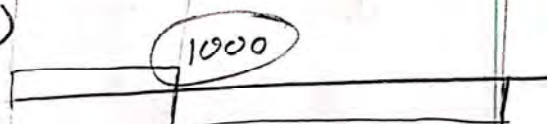
T(lb·in)



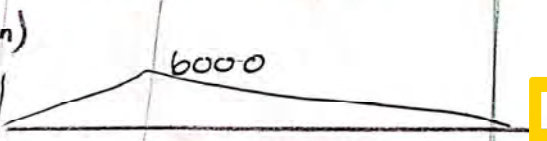
XZ analysis



V(lb)



M(lb·in)



T(lb·in)



(d) Critical locations:

@ A

$$= \sqrt{2076^2 + 6000^2}$$

$$= 6349$$

@ B

$$= \sqrt{-17233.2^2 + -1714^2}$$

$$= 17318.2$$

$$\sum M_o = 0$$

$$F_t \times 6 + F_c \times 21 = 0$$

$$F_c = -285.7 \text{ lb}$$

$$+\uparrow \sum F_y = 0$$

$$F_o + F_t + F_c = 0$$

$$F_o = 714.3 \text{ lb}$$

→ B critical location

$$M_a = 17318.2 \text{ lb·in}$$

$$T_m = 5000 \text{ lb·in}$$

Page: 2

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 10:22:26 AM
Nice V&M diagrams. Units and values at all key locations are provided.

 Number: 2 Author: japark Subject: Sticky Note Date: 12/15/2020 10:22:39 AM
Units are missing.

e.) factor of safety

$$\frac{1}{n} = \frac{8A}{\pi d^3 S_e} \left\{ 1 + \left[1 + \left(\frac{2B S_e}{A S_{ut}} \right)^2 \right]^{1/2} \right\}$$

$$A = \sqrt{4(k_f M_a)^2 + 3(k_{fs} T_a)^2}$$

$$B = \sqrt{4(k_f M_m)^2 + 3(k_{fs} T_m)^2}$$

Table A-20

$$S_{ut} = 85 \text{ kpsi}$$

$$S_e = \frac{1}{2}(85) = 42.5 \text{ kpsi}$$

$$S_e = k_a k_b k_c S_e'$$

Assume

$$k_b = 0.85$$

$$k_c = 1$$

$$k_a = a S_{ut}^b = 2.70(85)^{-0.265}$$

$$k_a = 0.832$$

$$S_e = 0.832 \times 0.85 \times 1 \times 42.5 = 30.1 \text{ kpsi}$$

Figure 6-20

$$q = 0.61 - 0.63$$

$$k_f = 1 + q(k_t - 1)$$

Fig. 6-21

$$q = 0.68 - 0.70$$

$$k_{fs} = 1 + q(k_{ts} - 1)$$

$$k_{ts} = 3.0$$

Table:
7-1

$$k_t = 2.14$$

$$k_f = 1 + 0.62(2.14 - 1)$$

$$k_f = 1.72$$

$$k_{fs} = 1 + 0.69(3.0 - 1)$$

$$k_{fs} = 2.38$$

$$A = \sqrt{4(1.72 \times 17318.2)^2}$$

$$A = 59574.6$$

$$B = \sqrt{3(2.38 \times 5000)^2}$$

$$B = 20611.4$$

$$\frac{1}{n} = \frac{8(59574.6)}{\pi(1.5)^3 \times 30.1 \times 10^3} \left\{ 1 + \left[1 + \frac{2(20611.4) \times 30.1 \times 10^3}{59574.6 \times 85 \times 10^3} \right]^2 \right\}^{1/2}$$

Assume

$$a = 3 \quad L_R = 10^6$$

$$Z = 10,000 \text{ hr}$$

$$g.) C_{10@0} = F_D F_D \left(\frac{L_D}{L_R} \right)^{1/a}$$

$$= 1187.4 \left(\frac{10,000 \times 2000 \times 60}{10^6} \right)^{1/3} F_{De0} = \sqrt{948.5^2 + 714.3^2}$$

$$F_{De0} = 1187.4$$

$$C_{10@0} = 5856.76 \text{ lb} \times \frac{0.00444 \times 22 \text{ kN}}{1 \text{ lb}} = \boxed{C_{10@0} = 26.05 \text{ kN}}$$

$$C_{10@c} = 2886.4 \left(\frac{10,000 \times 2000 \times 60}{10^6} \right)^{1/3}$$

$$F_{De c} = \sqrt{-2877.2^2 + -285.7^2}$$

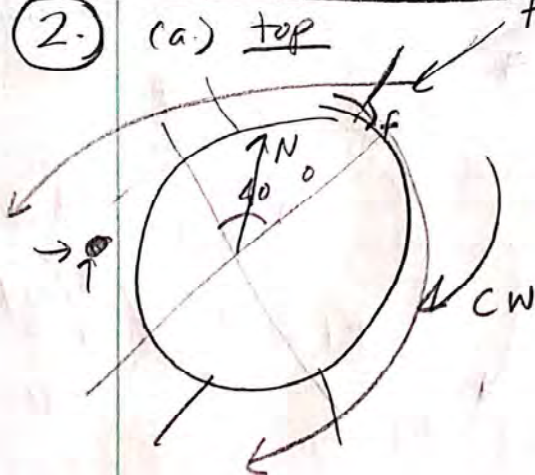
$$C_{10@c} = 14236.9 \text{ lb} \times \frac{0.00444 \times 22 \text{ kN}}{1 \text{ lb}} F_{De c} = 2886.4$$

$$\boxed{C_{b@c} = 63.33 \text{ kN}}$$

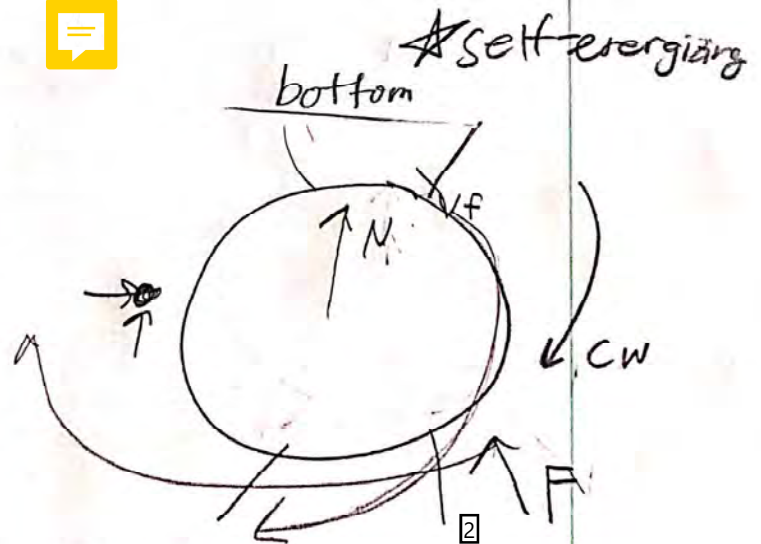
①

2.)

(a) top



bottom



$$(b.) \theta_1 = \frac{180 - 40}{2} = 70^\circ$$

$$\theta_2 = \theta_1 + 40 = 110^\circ$$

$$\theta_a = 90^\circ$$

Page: 4

	Number: 1	Author: japark	Subject: Sticky Note	Date: 12/15/2020 10:23:13 AM
Very good. There were mistakes but they were minor. 35/35				

	Number: 2	Author: japark	Subject: Sticky Note	Date: 12/15/2020 10:25:11 AM
fdN should be straight and tangent to the drum or shoe. -2				

c.) bottom

$$\sum M = 0$$

$$M_N - M_f - Fc = 0$$

$$\frac{M_N - M_f}{c} = F$$

Assume

$$a = 15 \text{ in}$$

$$c = 30 \text{ in}$$

$$b = 0.5 \text{ in}$$

$$f = 0.23$$

$$r = 6 \text{ in}$$

d.)

$$M_N = \frac{p a b r a}{\sin \theta a} \int_{\theta_1}^{\theta_2} \sin^2 \theta d\theta$$

$$= \frac{10 \text{ kpsi} \times 0.5 \times 6 \times 15}{\sin 90^\circ} \int_{70^\circ}^{110^\circ} \sin^2 \theta d\theta$$

$$M_N = 9000 \quad 1$$

$$M_f = \frac{f p a b r}{\sin \theta a} \int_{\theta_1}^{\theta_2} \sin \theta (r - a \cos \theta) d\theta$$

$$M_f = \frac{0.23 \times 10 \text{ kpsi} \times 0.5 \times 6}{\sin 90^\circ} \int_{70^\circ}^{110^\circ} \sin \theta (6 - 15 \cos \theta) d\theta$$

$$M_f = 28.32 \quad 2$$

$$F = \frac{9000 - 28.32}{30} = 299.1 \text{ lb}$$

Page: 5

	Number: 1 unit is missing.	Author: japark	Subject: Sticky Note	Date: 12/15/2020 10:23:56 AM
	Number: 2 kip-in?	Author: japark	Subject: Sticky Note	Date: 12/15/2020 10:24:26 AM
	Number: 3 Probably good idea to check the calculation. There seems to be too much of discrepancy between Mn and Mf.	Author: japark	Subject: Sticky Note	Date: 12/15/2020 10:25:05 AM

c.) non-self energizing

$$F = \frac{M_N + M_F}{c} = \frac{900 \text{ Pa} + 2.832 \text{ Pa}}{30}$$

$$299.11 \text{ lb} = 30.0944 \text{ Pa}$$

$$Pa = 9.93 \text{ lb}$$

$$f.) T = \frac{f p a b r^2 (\cos \theta_1 - \cos \theta_2)}{\sin \theta a}$$

$$T_{\text{top}} = \frac{0.23 \times 9.93 \times 0.5 \times 6^2 (\cos 70^\circ - \cos 110^\circ)}{\sin 90^\circ}$$

$$T_{\text{top}} = 28.12$$

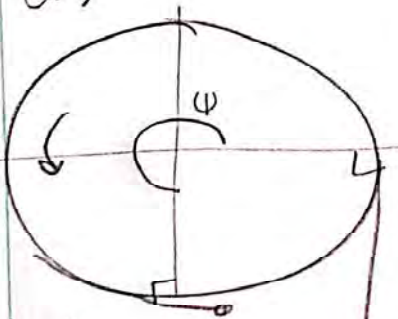
$$T_{\text{total}} = 56.44 \text{ lb/in}$$

$$T_{\text{bottom}} = \frac{0.23 \times 10 \times 0.5 \times 6^2 (\cos 70^\circ - \cos 110^\circ)}{\sin 90^\circ}$$

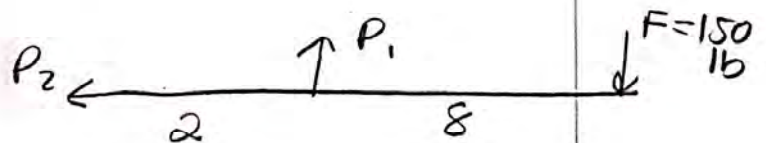
$$T_{\text{bottom}} = 28.32$$

b.)

3.



lower tension



$$\frac{P_1}{P_2} = e^{f\psi}, T = (P_1 - P_2) \frac{D}{2}, p = \frac{2P}{bD}$$

$$(c.) \sum M_o = 0$$

$$-F \times 10 + P_1 \times 2 = 0$$

$$P_1 = 750 \text{ lb}$$

$$\psi = 270 \times \frac{\pi}{180} = 4.71 \text{ rad}$$

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 10:25:52 AM
I can see that you clearly understand the material here. 33/35

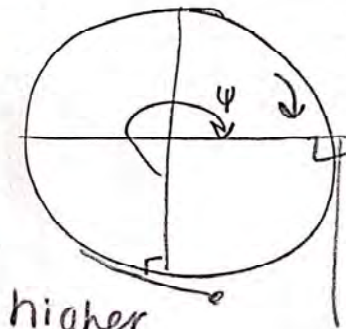
$$P_1 = 750 \text{ lb}$$

$$\frac{P_1}{P_2} = e^{f\psi} = \frac{P_1}{P_2} = e^{0.25 \times 4.71}$$

$$\frac{750 \text{ lb}}{P_2} = 3.246 \rightarrow 750 \text{ lb} = 3.246 P_2$$

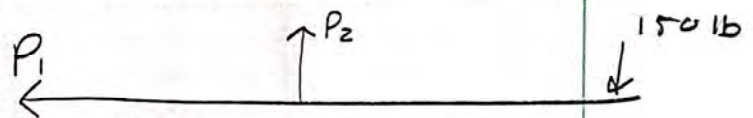
$$P_2 = 231.1 \text{ lb}$$

d.)



higher tension

lower tension



$$\sum M_{P_1} = 0$$

$$-150 \times 10 + P_2 \times 2 = 0$$

$$P_2 = 750 \text{ lb}$$

$$\frac{P_1}{P_2} = e^{f\psi} = \frac{P_1}{P_2} = e^{0.25 \times 4.71}$$

$$\frac{P_1}{750 \text{ lb}} = 3.246 \rightarrow P_1 = 750 \times 3.246$$

$$P_1 = 2434.5 \text{ lb}$$



1

Average

Final Exam

1.) $\omega = 1000 \text{ rpm}$
 $F_A = 1500 \text{ lbf}$
 $\phi = 20^\circ$
 $d_A = 10 \text{ in}$
 $d_p = 4 \text{ in}$
 $n = 3$

Sharp fillet

Square key

$d_{\text{shaft}} = 1.5 \text{ in}$

AISI 1045 CD steel

Tight side = 4 (loose side)

Using right hand,
 T_2 is tight side

$$T_2 = 4T_1$$

a.) $T_A = F_A \cos(20^\circ) (5 \text{ in})$
 $= (1500 \text{ lbf}) \cos(20^\circ) (5 \text{ in})$
 $T_A = 7047.7 \text{ lbf}\cdot\text{in}$

$$\sum T = 0$$

$$T_A - T_2 (3 \text{ in}) - T_1 (3 \text{ in}) = 0$$

$$T_A = (T_1 + T_2) (3 \text{ in})$$

$$T_A = (T_1 + 4T_1) (3 \text{ in})$$

$$7047.7 \text{ lbf}\cdot\text{in} = (5T_1) (3 \text{ in})$$

$$+783.1 \text{ lbf} = T_1$$

$$4T_1 = T_2$$

$$4(+783.1) =$$

$$+3132.31 \text{ lbf} = T_2$$

Summary of Comments on 2020-12-07 09:32

Page: 1

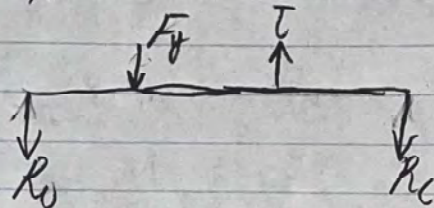


Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 10:28:27 AM

T1 should be greater than T2. If T2 is greater, then torque balance will not be achieved.

b.)

XY-Plane



$$\sum M_0 = 0$$

$$-F_y(6\text{ in}) + T(15\text{ in}) + R_c(24\text{ in}) = 0$$

$$-1500\sin(20)(6\text{ in}) + 3915.39(15) + R_c(24) = 0$$

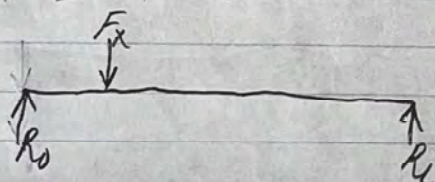
$$R_c = -2650.12 \text{ lbf}$$

$$\sum F_y = 0$$

$$R_0 - F_y + T + R_c = 0$$

$$R_0 = -752.23 \text{ lbf}$$

XZ-Plane



$$\sum M_0 = 0$$

$$-F\cos(20^\circ)(6\text{ in}) + R_c(21\text{ in}) = 0$$

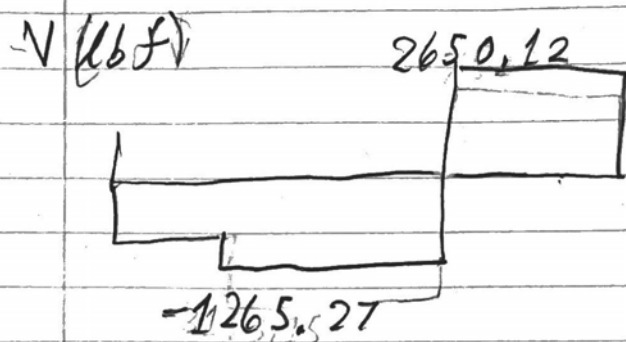
$$R_c = 402.73 \text{ lbf}$$

$$\sum F_z = 0$$

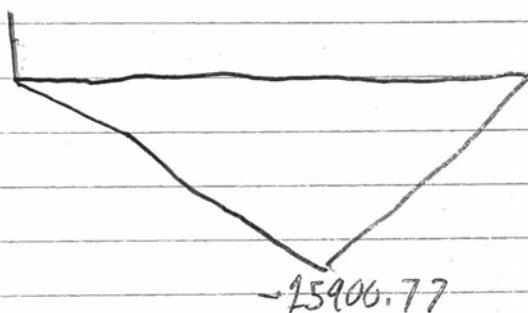
$$-F\cos(20^\circ) + R_c + R'_0 = 0$$

$$R'_0 = 1006.81 \text{ lbf}$$

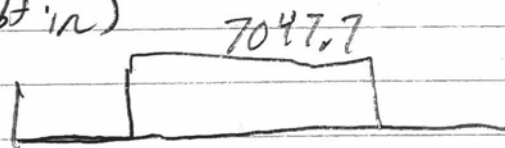
C) XY-Plane



M (lbf·in)

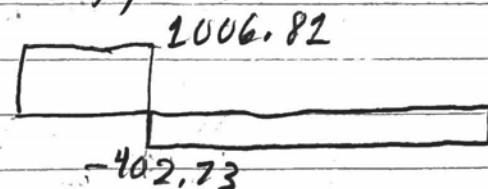


T (lbf·in)

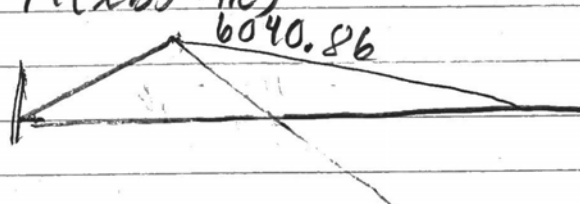


XZ-Plane

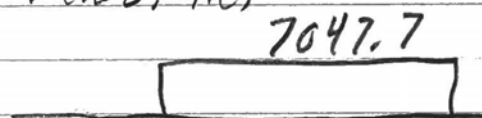
V (lbf)



M (lbf·in)



T (lbf·in)



D) $M_{total} = \sqrt{M_{xy}^2 + M_{xz}^2}$

$$= \sqrt{(-15900.77)^2 + (6040.86)^2}$$

$$M_{total} = 17009.6 \text{ lbf·in}$$

$$T_{total} = 7047.7 \text{ lbf·in}$$

$$e.) \quad n = \left(\frac{8A}{\pi d^3 S_e} \left[1 + \left(1 + \left(\frac{2BS_e}{AS_{ut}} \right)^2 \right)^{1/2} \right] \right)^{-1}$$

$$A = \sqrt{4(K_f M_a)^2}$$

$$B = \sqrt{3(K_{fs} T_m)^2}$$



$$S_{ut} = 91 \text{ Kpsi}$$

$$S_e' = .5 S_{ut}$$

$$S_e' = 45.5 \text{ Kpsi}$$



Page: 4

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 10:29:30 AM
Kf, Kfs, and Marin factor analysis are missing -5

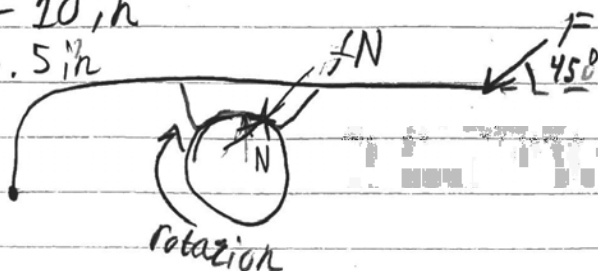
 Number: 2 Author: japark Subject: Sticky Note Date: 12/15/2020 10:29:08 AM
Part f and g are missing -10

 Author: japark Subject: Sticky Note Date: 12/15/2020 10:29:41 AM
20/35

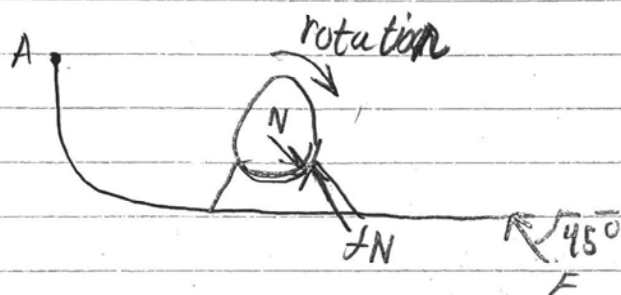
FIVE STAR.
★★★★★

2.) $b = .5 \text{ in}$
 $f = .27$
 $d = 10 \text{ in}$
 $a = .5 \text{ in}$

a.)



FIVE STAR.
★★★★★



1

Bottom
side is self
Energizing!

FIVE STAR.
★★★★★

b.) $\theta_1 = 65^\circ$
 $\theta_2 = 115^\circ$
 $\theta = 90^\circ$

2

c.) $\Sigma M_A = 0$
 $-M_N + M_f + Fc = 0$
 $F = \frac{M_N - M_f}{c}$

3

FIVE STAR.
★★★★★

$$R_x = \frac{p_a b r}{\sin(\theta_a)} \left(\int_{\theta_1}^{\theta_2} \sin(\theta) \cos(\theta) (d\theta) - f \int_{\theta_1}^{\theta_2} \sin^2(\theta) (d\theta) \right) - F_x$$

$$R_y = \frac{p_a b r}{\sin(\theta_a)} \left(- \int_{\theta_1}^{\theta_2} \sin^2(\theta) (d\theta) - f \int_{\theta_1}^{\theta_2} \sin(\theta) (d\theta) \right) + F_y$$



Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 10:31:12 AM

Difficult to see the direction of f_{dN} . Also, the moment generated by the actuation force (F) and the moment generated by the friction force are in the opposite direction. Thus, the bottom side is NOT self energizing.



Number: 2 Author: japark Subject: Sticky Note Date: 12/15/2020 10:31:29 AM

Show your work on how θ_1 is 65 degrees.



Number: 3 Author: japark Subject: Sticky Note Date: 12/15/2020 10:33:32 AM

Calculating the moment arm for F with respect to the hinge is not trivial. In this case, it would be better to separate the actuation force into two components (horizontal and vertical). Then, moment arm calculation becomes very easy.

$$d) p_a = 15 \text{ kpsi} = 15000 \text{ psi}$$

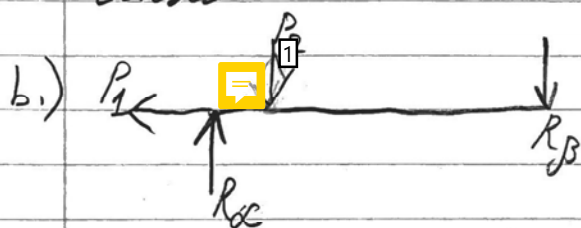


1

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 10:34:00 AM
Part d, e, and f are missing.

3.) $d = 7\text{ in}$
 $\alpha = 2\text{ in}$
 $\beta = 8\text{ in}$
 $f = .2$
 $E_w = 1\text{ in}$
 $F = 200\text{ lbf}$
 clockwise

a.) The left side will experience higher tension



c.) $T = (P_1 - P_2)^{1/2} = 200\text{ lbf}^{1/2}$

$P_1 - P_2 = 200\text{ lbf}$

$\frac{P_1}{P_2} = e^{f(\frac{3\pi}{2})}$

$= e^{.2(\frac{3\pi}{2})}$

$P_1 = 2.57 P_2$

$2.57 P_2 - P_2 = 200\text{ lbf}$

$P_2 = 127.39\text{ lbf}$

Page: 7

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 10:34:23 AM
Hinge pin reaction is missing.

 Number: 2 Author: japark Subject: Sticky Note Date: 12/15/2020 10:35:22 AM
Why is $P1 - P2 = 200 \text{ lbf}$? The amount of $P2$ should be computed via moment balance about the hinge.

 Number: 3 Author: japark Subject: Sticky Note Date: 12/15/2020 10:35:27 AM
18/30

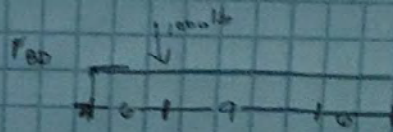
Below Average

2 $F = 1000$ 2000 cph 10 inch diameter Airsp 10440 CD 3mm

$$1000 (5) = 5000 \text{ lb}$$

$$T_{\text{gap}} = 5000 = \frac{(\pi \cdot \eta \cdot A)}{(T_1 - T_2)}$$

$$\frac{\eta A}{\pi d^3 \text{se}} \left[1 + \left(\frac{2850}{A \text{se}} \right)^2 \right]^{1/2}$$



Summary of Comments on Binder1.pdf

Page: 1



Number: 1

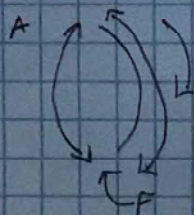
Author: japark

Subject: Sticky Note

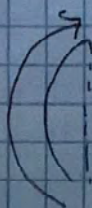
Date: 12/15/2020 11:58:26 AM

Partial credit +10

2



right



left

1

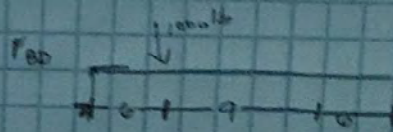
 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 11:58:44 AM
Partial credit +5

2 $F = 1000$ 2000 cph 10 inch diameter Airsp 10420 CD 3mm

$$1000 (5) = 5000 \text{ lb}$$

$$T_{\text{gap}} = 5000 = \frac{(\pi \cdot \eta \cdot A)}{(T_1 - T_2)}$$

$$\frac{\eta A}{\pi d^3 \text{se}} \left(1 + \left(\frac{2850}{A \text{se}} \right)^2 \right)^{1/2}$$



 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 11:59:15 AM
This is not a solution for P3.

0/30

IV. QUIZZES

MACHINE DESIGN II FALL 2020

TITLE OF ASSIGNMENT: QUIZ 1

TOPICS COVERED IN QUIZ I

1. Gears – General
 - a. Gear Fundamentals
 - b. Gear Train
 - c. Force Analysis

Quiz 1

⚠ This is a preview of the published version of the quiz

Started: Dec 15 at 1:34pm

Quiz Instructions

You have until 9:15 AM to complete and submit your work. Any work submitted after 9:15 AM is considered late.

If you start right at 8:05 AM, you will have a total of 70 minutes.

This quiz has two problems. Your work on each question should be scanned and submitted separately.

If you believe any information is missing, make a reasonable assumption, and state why you are making that assumption.

Do not misuse the internet (e.g., asking solutions on Chegg, googling problem solutions, etc.) They are considered academic misconduct.

Question 1

10 pts

A pair of spur gear having a diametral pitch of 5 teeth/in is being used to generate a 2:1 speed *decrease*. The distance of this setup is measured to be 8 inches. Compute the following,

- a. Number of teeth for both gear
- b. Circular pitch
- c. Radii of the base circle
- d. Would you expect interference to be a problem for this gear mesh? Show your work.

Upload

Choose a File

Next ▶

Quiz saved at 1:34pm

Submit Quiz

Quiz 1



You started this quiz near when it was due, so you won't have the full amount of time to take the quiz.



⚠ This is a preview of the published version of the quiz

Started: Dec 15 at 1:34pm

Quiz Instructions

You have until 9: 15 AM to complete and submit your work. Any work submitted after 9:15 AM is considered late.

If you start right at 8:05 AM, you will have a total of 70 minutes.

This quiz has two problems. Your work on each question should be scanned and submitted separately.

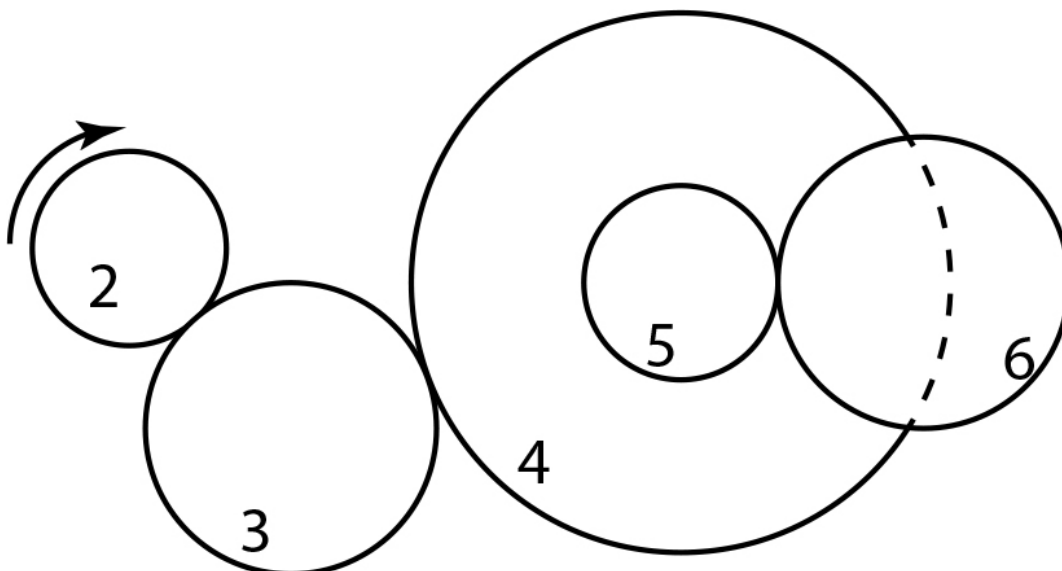
If you believe any information is missing, make a reasonable assumption, and state why you are making that assumption.

Do not misuse the internet (e.g., asking solutions on Chegg, googling problem solutions, etc.) They are considered academic misconduct.

Question 2

10 pts

A 15 hp motor drives the gear train shown in the figure. The pinion (gear 2) is rotating at 200 rpm. All gears have a diametral pitch of 10 teeth/in and a pressure angle of 20 deg. $N_2 = 30$, $N_3 = 45$, $N_4 = 100$, $N_5 = 30$, $N_6 = 45$. Compute the following,



a. What is the train value of this gear train?

b. Calculate the rpm of gear 5.

c. Draw

Compute the transmitted load (F_t) on gear 4 and 5. (hint: tye are not equal)

✓ You started this quiz near when it was due, so you won't have the full amount of time to take the quiz. ✕

shaft.

Upload

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◀ Previous

Not saved

Submit Quiz

Problem 1

$$P = 5 \text{ t/in}, \quad n = 2, \quad C = 8 \text{ in}$$

$$\frac{N_g}{N_p} = 2 \quad \text{--- (1)} \quad P = \frac{N}{d} \Rightarrow d = \frac{N}{P} \Rightarrow \frac{N_g}{2P} + \frac{N_p}{2P} = 8 \quad \text{--- (2)}$$

$$\begin{aligned} \text{a) } 2N_p &= N_g & N_g + N_p &= 8 \cdot 2 \cdot 5 = 80 \\ 3N_p &= 80 & N_p &= \frac{80}{3} = 26.67 \text{ T} \sim 27 \text{ T} \\ & & N_g &= 54 \text{ T} \end{aligned}$$

$$\text{b) } \rho = \frac{\pi}{P} = 0.628 \text{ in/T}$$

$$\text{c) } r_{bp} = r_p \cos \phi \quad \phi = 20^\circ \quad \text{assumption}$$

$$r_{bp} = \left(\frac{27}{5} \right) \cos 20^\circ = 2.2 \text{ in}$$

$$r_{bg} = \left(\frac{54}{5} \right) \cos 20^\circ = 4.4 \text{ in}$$

$$\text{d) } N_p = \frac{2(1)}{(1+2(2)) \sin^2 20^\circ} \left(2 + \sqrt{2^2 + (1+2(2)) \sin^2 20^\circ} \right) \approx 15 \text{ T}$$

NO

Problem 2

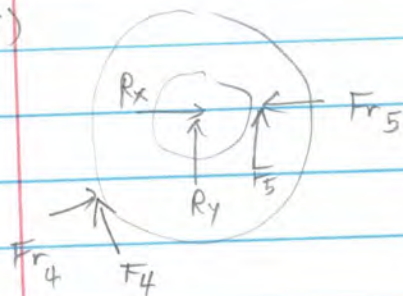
$$a) \quad n_3 = \frac{N_2}{N_3} n_2, \quad n_4 = \frac{N_3}{N_4} n_3, \quad n_5 = n_4, \quad n_6 = \frac{N_5}{N_6} n_5$$

$$n_6 = \frac{N_5}{N_6} \frac{N_3}{N_4} \frac{N_2}{N_3} n_2 = \frac{(30)(30)}{(45)(100)} 200 = 40 \text{ rpm}$$

$$e = 0.2$$

$$b) \quad n_4 = \frac{N_3}{N_4} \frac{N_2}{N_3} n_2 = \frac{(45)(30)}{(100)(45)} n_2 = \boxed{60 \text{ rpm}}$$

c)



$$F_4 = \frac{33000 \text{ hp}}{V} \quad \leftarrow V_4 = \frac{\pi d_4 n_4}{12}$$

$$= \frac{33000(15)}{15.71} = \frac{\pi \left(\frac{100}{10}\right)(60)}{12}$$

$$= 10505 \text{ lb} \quad 3150.8 \text{ lb} \quad = 15.71 \text{ ft/min}$$

$$F_5 = \frac{33000(15)}{\frac{\pi d_5 n_5}{12}} = \frac{10505 \text{ lb}}{15.71}$$

Above Average

1) Given

Diametral pitch (P) = 5 teeth/in

Speed decrease ratio (m_g) = 2:1

Distance of setup (d) = 8 in

- Relevant Equations

$$N_p \geq \frac{2K}{(1+2m)\sin^2 \phi} \left(m + \sqrt{m^2 + [1+2m]\sin^2 \phi} \right)$$

Assuming typical 20° pressure angle

- Ratio is less than 10:1

$K=1$ (full depth)

$$N_p \geq \frac{2(1)}{(1+2(2))\sin^2 20^\circ} \left(2 + \sqrt{2^2 + [1+2(2)]\sin^2 20^\circ} \right)$$

2) $N_p \geq 14.15$ so $N_p = 15$ pinion teeth

$$N_g = \frac{N_p^2 \sin^2 20^\circ - 4K^2}{4K - 2N_p \sin^2 \phi} = \frac{15^2 \sin^2 20^\circ - 4(1)^2}{4(1) - 2(15)\sin^2 20^\circ}$$

$N_g = 45.49$ so $N_g = 45$ teeth

b) Circular pitch (p)

$$p = \frac{\pi}{P} = \frac{\pi}{5 \frac{\text{teeth}}{\text{in}}} = 0.63 \frac{\text{teeth}}{\text{in}}$$

↑ given (diametral pitch)

c) Radii of base circle

$$d_1 = \frac{N_1}{P} = \frac{15}{5} = 3 \text{ in}$$

$$d_2 = \frac{N_2}{P} = \frac{45}{5} = 9 \text{ in}$$

d) Interference

$$m_G = \frac{N_G}{N_P} = \frac{45}{15} = 3$$

$m_G > 1$ then N_P can be 15 teeth as calculated in part A

So no interference at $N_P = 15$

$$N_G = 45$$



Summary of Comments on CamScanner 09-16-2020

09.13.26

Page: 2



Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:06:45 PM

The number of teeth should be computed using center to center distance with gear ratio. The way you calculated number of teeth does not guarantee center to center distance of 8 inches. However, I understand that problem statement was not clear. No points have been taken off.

Did not answer
part c

2) Given

15 hp motor

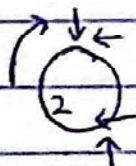
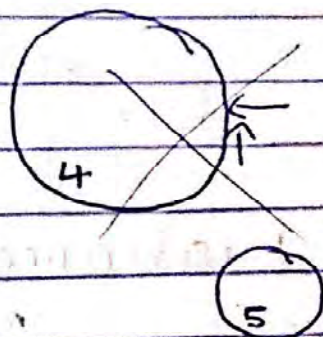
200 rpm ~~200~~ $= n_2$

$P = 10$ teeth/inch

$\phi = 20^\circ$

FBD of 4 & 5

c)



$F_T = ?$

a) train value (e)

~~$d_2 = \frac{N_2}{P} = \frac{30}{10} = 3$ in~~ $d_2 = \frac{N_2}{P} = \frac{30}{10} = 3$ in

$$d_3 = \frac{45}{10} = 4.5 \text{ in}$$

$$d_5 = \frac{30}{10} = 3 \text{ in}$$

$$d_4 = \frac{100}{10} = 10 \text{ in}$$

$n_6 =$ last gear speed

$$n_6 = \frac{d_5}{d_6} (200) = 133.33$$

$$n_L = e n_F \Rightarrow e = \frac{n_L}{n_F} = \frac{133.33}{200} = 0.6$$

$$e = 0.6$$

b) RPM of gear 5

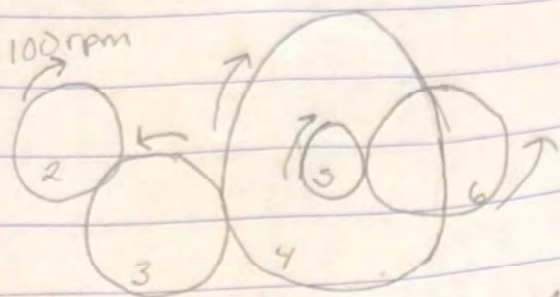
$$n_5 = \frac{d_4}{d_5} n_4 = \frac{10}{3} (133.3) = 444.4 \text{ rpm}$$

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:06:56 PM
Freebody diagram is not complete (-1). Force calculation is missing (-1) but other than part c, very good job.

We will go over the quiz next Monday during class. Hopefully that clarifies some of the concepts. If you need further assistance, feel free to let me know.

Average

2)



Driving - 2, 3, 5

Driven - 4, 6

$P = \text{Steel}/\text{in}$

$\phi = 20^\circ$

$N_2 = 40 \quad N_4 = 100$

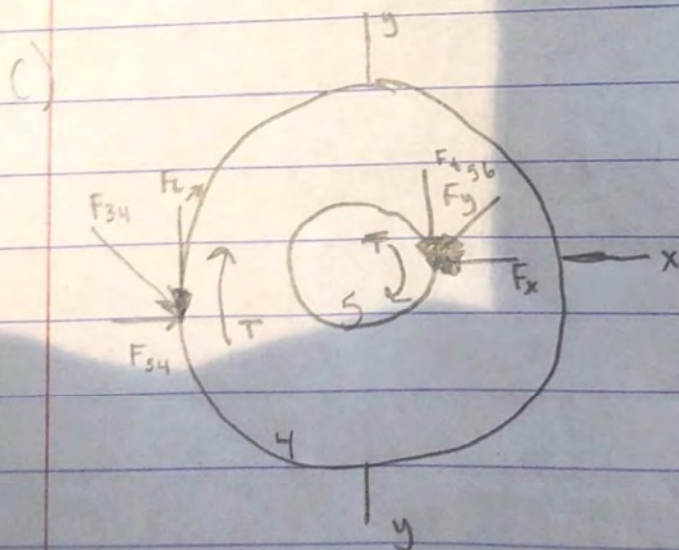
$N_3 = 60 \quad N_5 = 40$

$N_6 = 60$

$$a) \quad e = \frac{(40)(60)(40)}{(100)(60)} = \frac{96000}{6000} = 16$$

$$\left(\frac{N_2}{N_5}\right)\left(\frac{N_5}{N_6}\right) = \frac{40}{100} \left(\frac{40}{60}\right) = 0.264$$

2.64 rev/min



Summary of Comments on ScanPro Sep 16, 2020 9.10 AM.pdf

Page: 1



Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:08:38 PM

Train value should have all teeth count of driving/driven gears (-1), and since this is speed reduction gear e should be a value less than one.
Transmitted loads are in wrong direction (-1) force calculation is missing (-1)

We will go over the quiz next Monday during class. Hopefully that clarifies some of the concepts. If you need further assistance, feel free to let me know.

1) Given: $P = 5 \text{ teeth/in}$

$$C = 8 \text{ in}$$

$$n_p/n_g = N_p/N_g = 4$$

$$n_p/n_g = 3$$

$$4 = \frac{N}{40} = 10 \text{ teeth}$$

$$a) = P = \frac{N}{d} = 5 = \frac{10}{d} = 50 \text{ teeth}$$

$$b) p = \frac{\pi d}{N} \approx$$

C



1

Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:08:28 PM

The number of teeth should be computed using center to center distance with gear ratio. (-2) part b,c, and d are missing (-4)

Below Average

1)

Priscilla Djomo.

$$P = 5 \text{ teeth/in}$$

$$\frac{n_2}{n_1} = \frac{3}{1}, \quad C = 8 \Rightarrow C = \frac{r_1 + r_2}{2}$$

Find

a) Number of teeth for both gear

$$\frac{r_1}{r_2} = -\frac{n_2}{n_1} \Rightarrow \frac{r_1}{r_2} = \frac{3}{1} \Rightarrow \frac{r_1}{r_2} = 3$$

$$r_1 = 3r_2 \Rightarrow r_2 = \frac{1}{3}r_1$$

$$\text{So, } P = \frac{N}{d} \Rightarrow P_1 = \frac{N_1}{d_1} \Rightarrow P_1 = \frac{N_1}{\frac{3r_2}{2}}$$

$$P_1 \times \frac{3r_2}{2} = N_1 \Rightarrow N_1 = \frac{3P_1 r_2}{2}$$

$$N_1 = \frac{3 \times 5 r_2}{2} = \frac{15r_2}{2} = 7.5r_2$$

$$N_2 = P_2 \times \frac{1}{3}r_1 \Rightarrow N_2 = \frac{P_2}{3}r_1 \Rightarrow N_2 = \frac{5}{3}r_1$$

b) Find the circular pitch.

$$pP = \pi \Rightarrow p = \frac{\pi}{P} \Rightarrow p = \frac{3.14}{5}$$

$$p = 0.628 \text{ in}$$

Summary of Comments on New Document (38).pdf

Page: 1

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:11:11 PM
The number of teeth should be computed using center to center distance with gear ratio. (-1). Part c and d are missing (-3)

Problem 2 is missing. -10

MACHINE DESIGN II

FALL 2020

TITLE OF ASSIGNMENT: QUIZ 2

TOPICS COVERED IN QUIZ 2

1. Fatigue Failure Resulting from Variable Loading
 - a. The stress-life method
 - b. Stress concentration and notch sensitivity
 - c. Fatigue failure criteria for fluctuating stress

Quiz 2

⚠ This is a preview of the published version of the quiz

Started: Dec 15 at 1:57pm

Quiz Instructions

You have until 9: 15 AM to **complete and submit your work.**

If you start right at 9:05 AM, you will have a total of 70 minutes.

This quiz has two problems.

If you believe any information is missing, make a reasonable assumption, and state why you are making that assumption.

Do not misuse the internet (e.g., asking solutions on Chegg, googling problem solutions, etc.) They are considered academic misconduct.

Question 1

10 pts

A square rod with 1.75 in sides of AISI 1050 steel has a machined finish. The steel is heat-treated so that its tensile strength is 130 ksi. If the rod is subject to bending stress of 45 ksi, calculate the following.

- a. fully corrected endurance limit,
- b. fatigue safety factor
- c. if finite life is expected, estimate the number of cycles to failure.

Upload

Choose a File

Question 2

10 pts

A steel circular rod with a diameter of 2.5 in has a groove cut to a diameter of 2.3 in. The rod is made of AISI 1045 CD steel (tensile strength = 91 ksi) and is subject to a repeated axial load of 0 and 450 kips (kilopounds). Compute the number of cycles to failure using modified goodman criteria. Assume any information deemed necessary.

Upload

Not saved

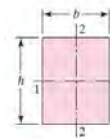
Quiz 2 – Problem 1

A square rod with 1.5 in sides of AISI 1040 steel has a machined finish. The steel is heat-treated so that its tensile strength is 120 ksi. If the rod is subject to bending stress of 40 ksi, calculate the following.

- fully corrected endurance limit,
- fatigue safety factor
- if finite life is expected, estimate the number of cycles to failure.

- $S_{ut} = 120 \text{ ksi}, S'_e = 0.5(120) = 60 \text{ ksi}$
- $k_a = aS_{ut}^b = (2.7)(120)^{-0.265} = 0.76$
- k_b requires diameter we do not have that
- $d_e = 0.808\sqrt{hb} = 0.808 \cdot 1.5 = 1.21 \text{ in}$
- $k_b = 0.879(1.21)^{-0.107} = 0.861$
- $k_c = 1$
- $S_e = 0.76 \cdot 0.861 \cdot 1 \cdot 60 \text{ ksi} = 39 \text{ ksi}$
- $n_f = \frac{S_e}{\sigma_{rev}} = \frac{39}{40} = 0.975$ – Finite life is expected
- Fatigue analysis
- $a = \frac{(fS_{ut})^2}{S_e}; b = -\frac{1}{3} \log\left(\frac{fS_{ut}}{S_e}\right)$
- $f = 0.9$
- $N = \left(\frac{\sigma_{rev}}{a}\right)^{\frac{1}{b}}$

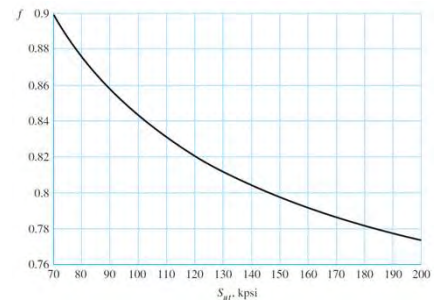
Surface Finish	Factor a		Exponent b
	S_{ut} kpsi	S_{ut} MPa	
Ground	1.34	1.58	-0.085
Machined or cold-drawn	2.70	4.51	-0.265
Hot-rolled	14.4	57.7	-0.718
As-forged	39.9	272	-0.995



$$A_{0.95\sigma} = 0.05hb$$

$$d_e = 0.808\sqrt{hb}$$

$$k_b = \begin{cases} (d/0.3)^{-0.107} = 0.879d^{-0.107} & 0.11 \leq d \leq 2 \text{ in} \\ 0.91d^{-0.157} & 2 < d \leq 10 \text{ in} \\ (d/7.62)^{-0.107} = 1.24d^{-0.107} & 2.79 \leq d \leq 51 \text{ mm} \\ 1.51d^{-0.157} & 51 < d \leq 254 \text{ mm} \end{cases} \quad (6-20)$$



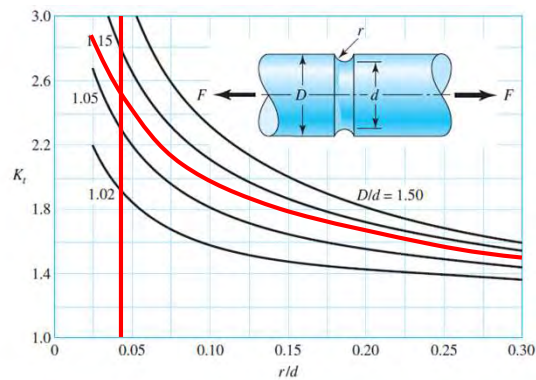
Quiz 2 – Problem 2

A steel circular rod with a diameter of 2.5 in has a groove cut to a diameter of 2.3 in. The rod is made of AISI 1045 CD steel (tensile strength = 91 ksi) and is subject to a repeated axial load of 0 and 450 kips (kilopounds). Compute the number of cycles to failure using modified goodman criteria. Assume any information deemed necessary.

- We have a notch! We need to find $K_f = 1 + q(K_t - 1)$
 - K_t from Figure A-15-13

Figure A-15-13

Grooved round bar in tension.
 $\sigma_0 = F/A$, where $A = \pi d^2/4$.



- $\frac{r}{d} = \frac{0.1}{2.3} = 0.043$
- $\frac{D}{d} = \frac{2.5}{2.3} = 1.1$
- $K_t = 2.5$

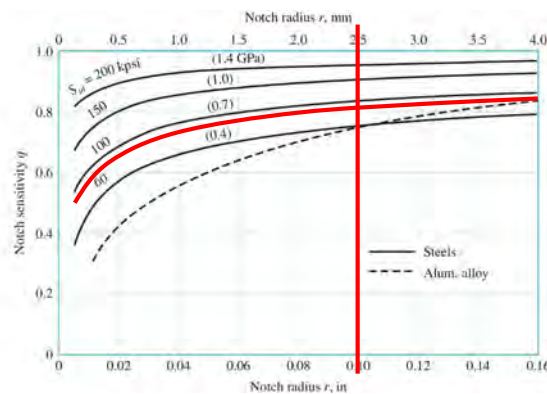
Quiz 2 – Problem 2

A steel circular rod with a diameter of 2.5 in has a groove cut to a diameter of 2.3 in. The rod is made of AISI 1045 CD steel (tensile strength = 91 ksi) and is subject to a repeated axial load of 0 and 450 kips (kilopounds). Compute the number of cycles to failure using modified goodman criteria. Assume any information deemed necessary.

- We have a notch! We need to find $K_f = 1 + q(K_t - 1)$
 - q from Figure 6-18

Figure 6-20

Notch-sensitivity charts for steels and UNS A92024-T wrought aluminum alloys subjected to reversed bending or reversed axial loads. For larger notch radii, use the values of q corresponding to the $r = 0.16$ -in (4-mm) ordinate. (From George Sines and J. L. Waisman (eds.), *Metal Fatigue*, McGraw-Hill, New York. Copyright © 1969 by The McGraw-Hill Companies, Inc. Reprinted by permission.)



- $q = 0.8$
- $\frac{D}{d} = \frac{2.5}{2.3} = 1.1$
- $K_f = 1 + q(K_t - 1) = 1 + 0.8(2.5 - 1) = 2.2$

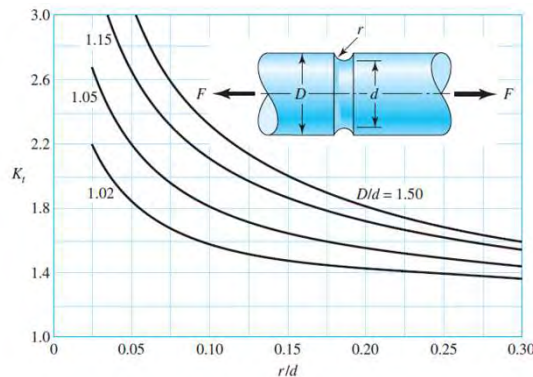
Quiz 2 – Problem 2

A steel circular rod with a diameter of 2.5 in has a groove cut to a diameter of 2.3 in. The rod is made of AISI 1045 CD steel (tensile strength = 91 ksi) and is subject to a repeated axial load of 0 and 450 kips (kilopounds). Compute the number of cycles to failure using modified goodman criteria. Assume any information deemed necessary.

- Now what?
- We need to calculate σ_{rev}
- The load is not completely reversed. Thus, the stress won't be completely reversed!
- We need to find σ_a and σ_m
- To find those we need to calculate σ_{max} and σ_{min}

Figure A-15-13

Grooved round bar in tension.
 $\sigma_0 = F/A$, where $A = \pi d^2/4$.



$$\begin{aligned}
 \bullet \quad \sigma_{max} &= \frac{F_{max}}{A} = \frac{450,000 \text{ lb}}{4.15 \text{ in}^2} = 108 \text{ ksi} \\
 \bullet \quad \sigma_{mi} &= 0 \\
 \bullet \quad \sigma_{m_0} &= \frac{\sigma_{min} + \sigma_{max}}{2} = 54 \text{ ksi} \\
 \bullet \quad \sigma_{a_0} &= \left| \frac{\sigma_{min} - \sigma_{max}}{2} \right| = 54 \text{ ksi}
 \end{aligned}$$

Quiz 2 – Problem 2

A steel circular rod with a diameter of 2.5 in has a groove cut to a diameter of 2.3 in. The rod is made of AISI 1045 CD steel (tensile strength = 91 ksi) and is subject to a repeated axial load of 0 and 450 kips (kilopounds). Compute the number of cycles to failure using modified Goodman criteria. Assume any information deemed necessary.

- Due to notch, we consider K_f to bring the stress up!
- $\sigma_a = K_f \sigma_{a0}; \quad \sigma_m = K_f \sigma_{m0}$
- $\sigma_a = 2.2(54) = 118.8 \text{ ksi}$
- $\sigma_m = 2.2(54) = 118.8 \text{ ksi}$
- Now we need to find equivalent σ_{rev}
- $\frac{\sigma_a}{\sigma_{rev}} + \frac{\sigma_m}{S_{ut}} = \frac{1}{1}$
- $\sigma_{rev} = \frac{\sigma_a}{1 - \frac{\sigma_m}{S_{ut}}} = \frac{118.8}{1 - \frac{118.8}{91}} = 129 \text{ ksi}$
- $\sigma_{rev} > S_{ut}$; this will not survive the first cycle.

Above Average

JAIBELL A D DESAI

MCEG 4043 Y02

QUIZ # 2

P21335547

①

Problem I

Square rod 1.5 in sides

$S_{ut} = 130 \text{ ksi}$

$\bar{\sigma} = 45 \text{ ksi}$

AISI 1040

Machine Finish

$$a) S_e = K_a \cdot K_b \cdot K_c \cdot K_d \cdot K_e \cdot K_f \cdot S'_e$$

$$\bullet S'_e = 0.5 \quad S_{ut} = 130 \cdot 0.5 = 65 \text{ ksi}$$

$$\bullet K_a = a \cdot S_{ut}^b$$

From Table 6-2 (Machined)

$$a = 2.70$$

$$b = -0.265$$

$$K_a = 2.70 \cdot 130^{-0.265} = 0.7433$$

• Equivalent Diameter (From Table 6-3)

$$d_e = 0.808 \sqrt{h \cdot b} = 0.808 \cdot \sqrt{1.5 \cdot 1.5} = 1.212 \text{ in}$$

$$d_e = 1.212 \text{ in}$$

$$\bullet K_b = 0.879 d_e^{-0.107} = 0.879 \cdot 1.212^{-0.107}$$

$$K_b = 0.8611$$

• $K_c = 1$ Bending loading

- $K_d = 1$ No temp given
- $K_e = 1$ NO reliability study
- $K_f = 1$ NO miscellaneous effects

(2)

$$S_e = 0.7433 \times 0.8611 \times 1 \times 1 \times 1 \times 1 \times 65 \text{ Ksi}$$

$$S_e = \underline{\underline{41.6036 \text{ Ksi}}}$$

b. According to mod - Goodman

$$\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{ut}} = \frac{1}{n} \quad \text{Assuming } \sigma_a = \sigma_m = 45 \text{ ksi}$$

$$\frac{45}{41.6036} + \frac{45}{130} = \frac{1}{n} \quad \text{solving } n$$

$$n = \underline{\underline{0.7004}}$$

c) From Figure 6-18

$$S_{ut} = 130 \text{ Ksi} \rightarrow f = 0.817$$

$$\sigma_{rw} = 45 \text{ ksi}$$

$$a = \frac{(f \times S_{ut})^2}{S_e} = \frac{(0.817 \times 130)^2}{41.6036} = 271.1439$$

$$a = \underline{\underline{271.1439}}$$

$$b = -\frac{1}{3} \log \left(\frac{f \cdot S_{ut}}{S_e} \right) = -\frac{1}{3} \log \left(\frac{0.817 \cdot 130}{41.6036} \right) \quad (3)$$

$$b = -0.3124$$

$$N = \left(\frac{S_{rev}}{a} \right)^{\frac{1}{b}} = \left(\frac{45}{271.1439} \right)^{\frac{1}{-0.3124}}$$

$$N = 313.876 \approx 313.88 = \underline{\underline{314 \text{ Cycles}}}$$

Problem II

$$D = 2.5 \text{ in}$$

AISI 1045 CD

$$d = 2.3 \text{ in}$$

$$S_{ut} = 91 \text{ ksi}$$

$$F_{min} = 0 \text{ kips}$$

$$F_{max} = 450 \text{ kips}$$

$$N = ?$$

$$\therefore r = \frac{D - d}{2} = \frac{2.5 - 2.3}{2} = 0.1 \text{ in}$$

$$\frac{r}{d_g} = \frac{0.1}{2.3} = 0.0435$$

$$\frac{D}{d_g} = \frac{2.5}{2.3} = 1.087$$

Summary of Comments on quiz 2.pdf

Page: 3

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:12:45 PM
No need to use the modified Goodman. n_f is endurance limit divided by the completely reversed stress which is already given. -1

(4)

From Figure A-15-13

$$k_t = 2.43$$

$$\bar{V}_a = 0.246 - 3.08 \times 10^{-3} \times S_{ut} + 1.51 \times 10^{-5} \times S_{ut}^2 - 2.67 \times 10^{-8} \times S_{ut}^3$$

$$\bar{V}_a = 0.246 - 3.08 \times 10^{-3} + 1.51 \times 10^{-5} \times 91^2 - 2.67 \times 10^{-8} \times 91^3$$

$$\bar{V}_a = 0.07064$$

$$q = \frac{1}{1 + \frac{\bar{V}_a}{\bar{V}_r}} = \frac{1}{1 + \frac{0.07064}{0.1}} = 0.81741$$

$$K_f = 1 + q (k_t - 1) = 1 + 0.8174 (2.43 - 1)$$

$$K_f = 2.1688$$

$$\bar{F}_a = F_m = \frac{F_{max}}{2} = \frac{450}{2} = 225 \text{ Kips}$$

$$\sigma_a = \sigma_m = \frac{K_f \times F_a}{A} = \frac{2.1688 \times 225}{\frac{\pi}{4} \times 2.3^2}$$

$$\sigma_a = 117.4509 \text{ Ksi} \approx 117.451$$

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:13:02 PM
Use the chart for q, much easier that way. Great, I can clearly see that you understand the concept.

$$S_e = 0.81699 * 1 + 0.85 * 45.5 * 1 * 1 * 1 \quad (5)$$

$$S_e = 31.5971 \text{ ksi}$$

• From Figure 6.18 $f = 0.857$

$$a = \frac{(f + S_{ut})^2}{S_e} = \frac{(0.857 * 91)^2}{31.5971} = 192.4851$$

$$b = -\frac{1}{3} \log \left(\frac{f + S_{ut}}{S_e} \right) = -\frac{1}{3} \log \left(\frac{0.857 * 91}{31.5971} \right)$$

$$b = -0.3012$$

$$N = \left(\frac{S_{rev}}{a} \right)^{\frac{1}{b}} = \frac{(117.4501)^{\frac{1}{-0.3012}}}{192.4851}$$

$$N = 5.15569 \approx \underline{6 \text{ cycles}}$$

Average

Kiern Beretta

Problem #1

Analysis	Assumptions	Physical laws
S_{ut} = tensile strength = 120 ksi = bending stress = 40 ksi $L = 1.5 \text{ in}$ Endurance limit? Fatigue safety factor? Finite Life is expected estimate the # of cycles of failure?	AISI 1040 Square rod $\sigma_m > 0$ heat treated ($T = 450^\circ\text{F}$) bending $K_d = S_T$ room temp. $[S_{ut} \leq 200 \text{ kpsi}]$ $S_e' = 0.5(S_{ut})$	$n_f = \frac{1}{\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{ut}}}$ ★ $n_f = \frac{1}{2} \left(\frac{S_{ut}}{\sigma_m} \right)^2 \frac{\sigma_a}{S_e} \left[-1 + \sqrt{1 + \left(\frac{2\sigma_m S_e}{S_{ut} + \sigma_a} \right)^2} \right]$ $K_a = a(S_{ut})^b$ $= 14.4(120)^{(-.718)}$ $a = 14.4 \text{ kpsi}$ $b = -.718$ $[K_a = .00473]$ $K_b = 1$ $K_c = 1$ $K_d = 1.007$ $K_e =$ $K_d = .975 + .432(10^{-3})(450) - .115(10^{-5})(450)^2 + .164(10^{-8})(450)^3 - .595(10^{-12})(450)^4$ $K_d = 1.0068$ $K_d = 1.007$ $(S_e)_{450^\circ} = K_d(S_e')$ $= K_d(0.5)(S_{ut})$ $(1.0068)(0.5)(120)$ $[S_e = 60.41 \text{ ksi}] \rightarrow$ Endurance limit $\left(\frac{S_T}{S_{ST}} \right) = 1.007$ (Interpolated)



$$N = \frac{\sigma_{rev}}{a}^{\frac{1}{b}}$$

$$\left(\frac{40}{14.4} \right)^{\frac{1}{-.718}}$$

$$N = 24.1(10^3) \text{ cycles}$$

Summary of Comments on A9R1p8ywq0_1rhz8f2_8d0.tmp

Page: 1



Number: 1

Author: japark

Subject: Sticky Note

Date: 12/15/2020 12:14:41 PM

We agreed that we are going to assume k_d , k_e , and k_f are equal to one for this class. No need to worry about the temperature factor. Please refer to the 10/7 lecture video for solutions. If that does not help feel free to let me know!

Problem #2 Analysis Assumptions Physical Law

$d = 2.5 \text{ in}$
Groove cut $d = 2.3 \text{ in}$

steel
AISI 1045
CD steel

$$\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{ut}} = \frac{1}{n}$$

$S_{ut} = \text{tensile strength} = 91 \text{ ksi}$

modified
goodman
criteria

$$\sigma_a = S_e$$

$$\sigma_{max} = S_y$$

$\sigma = \frac{\text{Axial Load}}{\text{Area}} = \frac{0}{\text{Area}}$
 $P = 450 \text{ Kips}$

$$S_a = ?$$

$$S_m = ?$$

$$\frac{S_a}{S_e} + \frac{S_m}{S_{ut}} = 1$$

compute the
of cycles
to failure

$$b = -6.265$$

S_{ut} Factor

$$S_m = \frac{(S_y - S_e) S_{ut}}{S_{ut} - S_e}$$

table (4-20)

$$[a = 2.70]$$

$$S_a = S_y - S_m$$

$$r_{crit} = \frac{S_a}{S_m}$$

$$S_{ut} = 91 \text{ Kpsi}$$

$$F_a = F_m = 8 \text{ Kip}$$

$$S_y = 77 \text{ Kpsi}$$

$$n_f = \frac{1}{\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{ut}}}$$

$$S_e = k_a k_b k_c k_d k_e k_f S_e'$$

$$\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{ut}}$$

$$k_a = a(S_{ut})^b$$

$$(-0.265)$$

$$\sigma_{rev} = \frac{\sigma_a}{1 - \frac{\sigma_m}{S_{ut}}} =$$

$$k_a = 2.70(91 \text{ Kpsi})^{-0.265}$$

$$[k_a = 0.8169]$$

$$k_b = 0.91d^{-0.157} = 0.91(2.5 \text{ in})^{-0.157} = [0.78807 = k_b]$$

$$[k_c = 0.85]$$

$$[k_d = k_e = k_f = 1]$$

$$S_e = (0.8169)(0.78807)(0.85)(1)(1)(1)(0.5)(91)$$

$$[S_e = 24.89 \text{ Kpsi}]$$

$$\sigma_{ao} = \frac{4F_a}{\pi d^2} = \frac{4(8 \text{ Kip})}{\pi (2.5 \text{ in})^2}$$

$$\sigma_{mo} = \frac{4F_m}{\pi d^2} = \frac{4(8 \text{ Kip})}{\pi (2.5 \text{ in})^2}$$

$$= \frac{32}{19.63}$$

$$[\sigma_{mo} = 1.629 \text{ Kpsi}]$$

$$[\sigma_{ao} = 1.629 \text{ Kpsi}]$$

$$n_f = \frac{1}{2} \left(\frac{S_e}{\sigma_{ao}} \right)^2 \left(\frac{\sigma_{mo}}{S_e} \right)$$

$$\times \left[-1 + \sqrt{1 + \left(\frac{2(\sigma_{ao} \times \sigma_{mo})}{S_e^2} \right)^2} \right]$$

$$= 102.11 \left(-1 + \sqrt{1 + \left(\frac{81.09}{144.839} \right)} \right)$$

$$102.11(-1 + \sqrt{1 + (.54702)^2})$$

$$n_f = 14.278$$

$$n_y = \frac{S_y}{\sigma_a + \sigma_m} = \frac{77}{1.629 + 1.629}$$

$$n_y = 23.63$$

$$N = \left(\frac{\sigma_{rev}}{a} \right)^{1/b}$$

$$\left(\frac{450}{2.70} \right)^{\frac{1}{-0.265}} = 3.7735$$

(166.166)

$$N = 4.127 \text{ cycles}$$

4127 cycles



Number: 1

Author: japark

Subject: Sticky Note

Date: 12/15/2020 12:15:02 PM

You assumed k_d , k_e , k_f equal to one here. Your alternating load is given as 0 and 450 kip. Where did 8 kip come from? You also need to compute the K_f since there is a notch. Try solving this equation following the flowchart I showed in the class today (10/7)

Below Average

Tips wurdard

Quiz 2

1. Given: 1.5 $\rightarrow$ AISI 1040 steel

$$T_s = 120 \text{ ksi}$$

$$\Rightarrow B_{s_{\text{res}}} = 120 \text{ ksi}$$

a)



~~DO NOT~~ Did not study correctly

Summary of Comments on CamScanner 10-05-2020 09.12.42

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Number: 1

Author: japark

Subject: Sticky Note

Date: 12/15/2020 12:15:50 PM

Partial credit for honesty. +2

$$2) \quad \frac{S_{er}}{S_r} + \frac{S_{en}}{S_n} = 1 \quad \frac{L_u}{S_{F/n}} + \frac{L_n}{S_{u/n}} = 1$$

$$S_r = \sigma_a' M c_a \quad S_e = S_{u/n} r$$

$$K_a = a \int_{a_r} b = 39.9 (8 \text{ km})^{-9}$$



1

Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:16:07 PM

I recommend you solve this problem following the flowchart I showed at the end of lecture 9. Then you will have much less room to make any mistakes. Here since your thing has a notch you need to consider the K_f . Also, since the load is not completely reversed, you need to compute the alternating and mean components of stress to find the equivalent completely reversed stress. Please refer to the 10/7 lecture video for solutions. If that does not help feel free to let me know!

 Author: japark Subject: Sticky Note Date: 12/15/2020 12:16:12 PM

Please let me know if you need help with fundamental things, I am here to help.

MACHINE DESIGN II
FALL 2020

TITLE OF ASSIGNMENT: QUIZ 3

TOPICS COVERED IN QUIZ 3

1. Shafts and Shaft Components
 - a. Review; Shear and Moment diagram

Quiz 3

⚠ This is a preview of the published version of the quiz

Started: Dec 15 at 2:04pm

Quiz Instructions

You have until 9: 15 AM to **complete and submit your work.**

If you start right at 8:05 AM, you will have a total of 70 minutes. Use your time wisely.

This quiz has two problems.

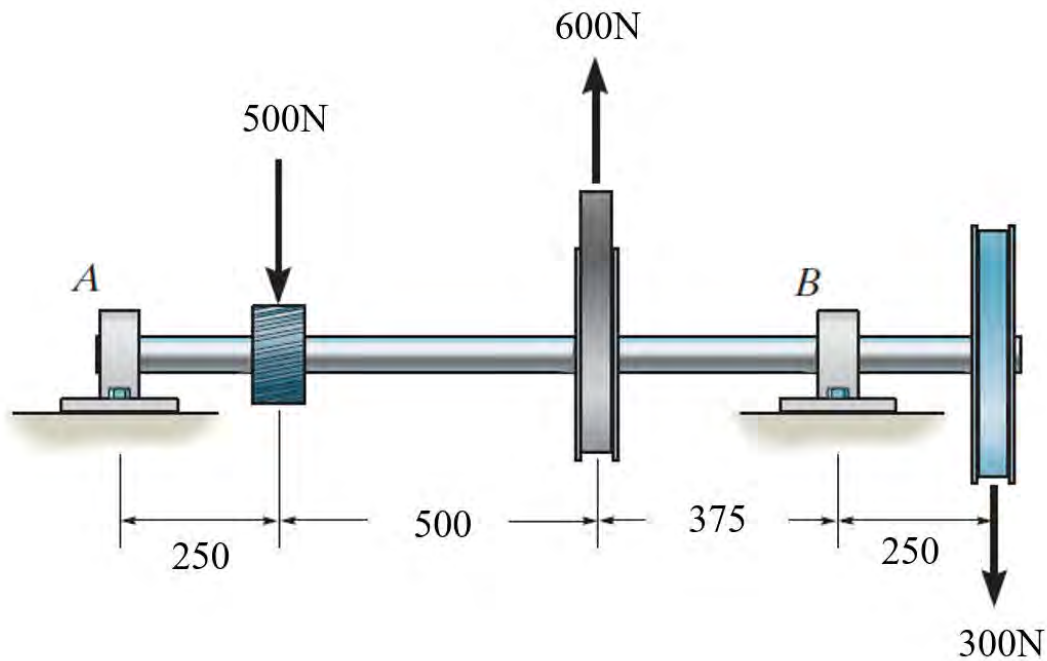
If you believe any information is missing, make a reasonable assumption, and state why you are making that assumption.

Do not misuse the internet (e.g., asking solutions on Chegg, googling problem solutions, etc.) They are considered academic misconduct.

Question 1

10 pts

A shaft is loaded with three vertical loadings as shown from three different components that are rotating at a constant speed with the shaft using end mill keyseats. The bearings at A and B are mounted against sharp shoulder fillet. The whole mechanism is driven by a motor (not shown) which results in 150 N-m of torque in the entire shaft. All lengths shown in the figure are in mm. If the shaft material is AISI1020 CD steel, and the safety factor is 2,



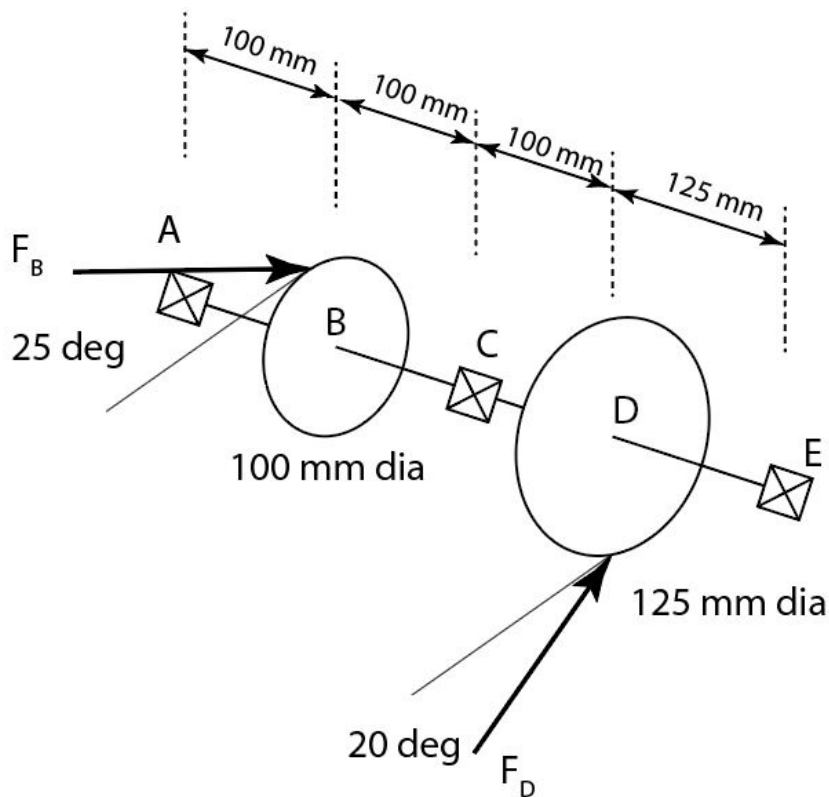
- Calculate reactions at the supports A and B
- Draw shear, moment, and torque diagram
- Where is the critical location?
- Estimate necessary fatigue stress concentration factors at the critical locations.
- Compute the fully corrected endurance limit.
- Set up the equation for appropriate diameter calculation using Modified Goodman criteria. You do not need to solve for the diameter.
- Suppose you obtained a diameter value from f, what is the next step?

Upload

Question 2

5 pts

Two spur gears with pressure angles shown are mounted on a shaft. The shaft is supported by bearings at A, C, and E. The gear and shaft system is driven by a pinion that exerts F_B on gear at B resulting 300 Nm of torque in the shaft that drives gear at D.



- a) Can you analyze this system using a single plane?
- a) Draw necessary free body diagram(s) and compute the reaction forces.
- b) Draw shear, moment, and torque diagrams.
- c) Based on your V, M, and T diagrams which location is the critical location?

Upload

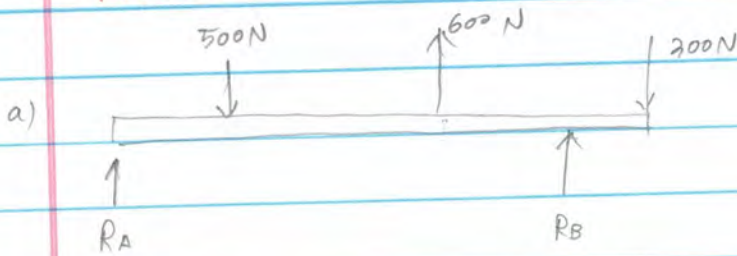
Choose a File

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Submit Quiz

Quiz 3

Problem 1

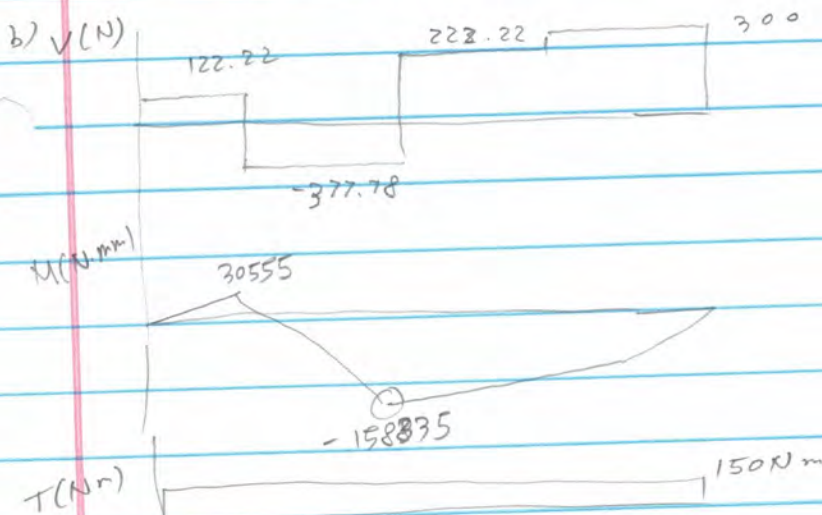


$$\sum M_A = 0; -500(250) + 600(750) + R_B(1125) - 300(1375) = 0$$

$$R_B = 77.78 \text{ N}$$

$$+\uparrow \sum F_y = 0; R_A - 500 + 600 + 77.78 - 300 = 0$$

$$R_A = 122.22 \text{ N}$$



c) location where 600N is applied would be the critical point

d) $K_t = 2.14$ $q = 0.8$ ($S_{ut} = 68 \text{ ksi}$)

$$K_f = 1 + 0.8(2.14 - 1) = 1.912$$

$$e) \quad K_a = a S_{ut}^b = 4.51 (500)^{-0.265} = 0.871$$

$$K_b = 0.85 \quad \leftarrow \text{assumption since } d \text{ is not given}$$

$$K_c = 1 \quad \leftarrow \text{bending only}$$

$$S_e' = 250 \text{ MPa}$$

$$S_e = K_a K_b K_c S_e' = 0.871 \times 0.85 \times 1 \times 250 \text{ MPa} = 185 \text{ MPa}$$

$$f) \quad d = \left(\frac{16(n)}{\pi} \right)^{1/3} \left\{ \frac{1}{S_e} \left[4(K_f M_a)^2 + 3(K_{fs} T_a)^2 \right]^{1/2} \right\}^{1/3}$$

$\swarrow$ 185 MPa $\swarrow$ 158335 Nmm $\swarrow$ 500 MPa $\swarrow$ 2.7 $\swarrow$ 150 Nm

Problem 2

problem 2 is voided due to an error in the problem.

students who put effort to solve this problem got full credit.

Above Average

1) Given

Did m. II keyseats, Sharp shoulder fillet, $T = 150 \text{ N}\cdot\text{m}$
 AISI 1020 CD Steel, $k = 2$

a) Supports @ A & B

$$T_m = T = 150 \text{ N}\cdot\text{m}$$

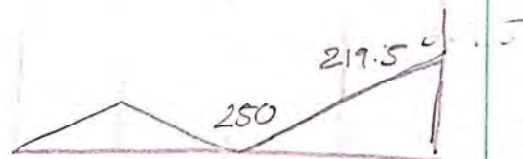
$$\sum M_A = 500 \times 250 - 600 \times 750 + B \times 1125 - 300 \times 1375 = 0$$

$$B = 878 \text{ N}$$

$$\sum F_y = A - 500 - 600 + 878 - 300 = 0$$

$$A = 552 \text{ N}$$

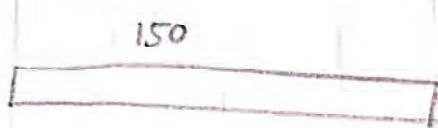
$$c) M_a = 219.5 \text{ N}\cdot\text{m}$$

M
(N·m)

$$d) \text{ Table A-20} \Rightarrow$$

$$S_{ut} = 68 \text{ Kpsi}$$

$$S_y = 57 \text{ Kpsi}$$

T
(N·m)

$$S_e' = 0.5(68) = 34 \text{ Kpsi}$$

$$S_e = k_a k_b k_c \times S_e'$$

$$k_a = a S_{ut}^b = 2.70(68)^{-0.265} = .90$$

$$* k_b = 0.85 \quad e) S_e = 0.90 \times 0.85 \times 0.59 \times 34 = 15.3 \text{ Kpsi}$$

$$k_c = 0.59$$

$$M_m = T_a = 0 \text{ steady state}$$

f) modified Goodman

$$d = \left(\frac{16n}{\pi} \left[\frac{1}{S_e} \left[4(K_f M_a)^2 + \frac{3(K_{fs} T_a)^2}{3(K_{fs} T_m)^2} \right]^{1/2} + \frac{1}{S_{ut}} \left[4(K_f M_m)^2 + \frac{3(K_{fs} T_m)^2}{3(K_{fs} T_m)^2} \right]^{1/2} \right] \right)^{1/3}$$

$$d = \left(\frac{16(2)}{\pi} \left[\frac{1}{15.3 \times 10^3} \left[4(2.19 \times 219.5)^2 \right]^{1/2} + \frac{1}{68 \times 10^3} \left[3(1.88 \times 150)^2 \right]^{1/2} \right] \right)^{1/3}$$

g) next step is to check k_b , a b q s to see if it is within allowable limits.

$$K_f = 1 + q(k_c - 1)$$

Figure (a-2.0)

$$q = 0.70$$

Table 7-1 → bearing locati

$$k_c = 2.7$$

$$k_f = 1 + 0.70(2.7 - 1)$$

$$k_f = 2.19$$

$$k_{f2} = 1 + q_2(k_{c2} - 1)$$

Figure (a-2.1)

$$q_2 = 0.73$$

$$k_{c2} = 2.2$$

$$k_{f2} = 1 + 0.73(2.2 - 1)$$

$$k_{f2} = 1.88$$

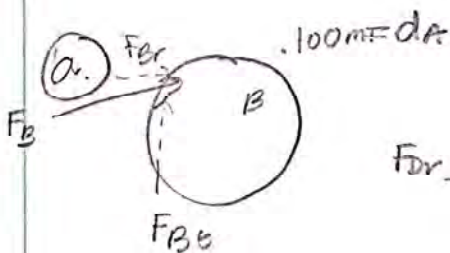


2.)

Given

$$T = 300 \text{ Nm}$$

(a) no because there are 2 forces @ different axes.



$$T = 300 \text{ Nm}$$

$$F_{Bt} = \frac{T}{r_B} = \frac{300 \text{ Nm}}{0.050 \text{ m}}$$

$$F_{Bt} = 6000 \text{ N}$$

$$F_{Br} = 6000 \tan 25^\circ$$

$$F_{Br} = 2798$$

$$F_{Dt} = \frac{T}{r_D} = \frac{300 \text{ Nm}}{0.0625} = 4800 \text{ N}$$

$$F_{Dr} = 4800 \tan 20^\circ = 1747$$

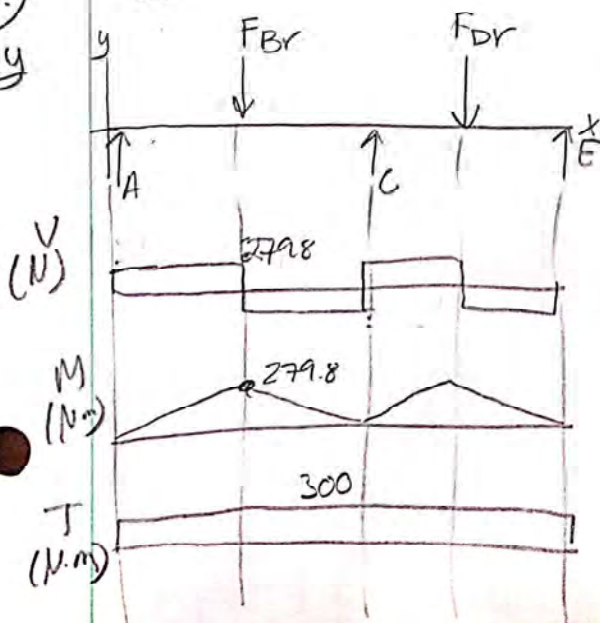
Assume

$$A = C = 1374 \text{ N}$$

$$\sum \circlearrowleft M_A = E \times 0.425 - F_{Br} \times 0.325 + C \times 0.175 - F_{Dr} \times 0.125$$

$$E = 2087 \text{ N}$$

(b.)
xy



Summary of Comments on Louis-MCEG 4043 Quiz 3

Page: 2



Number: 1

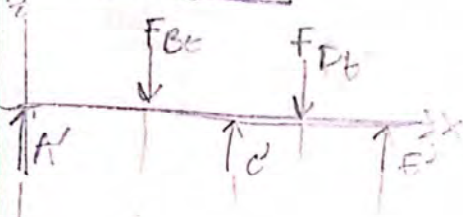
Author: japark

Subject: Sticky Note

Date: 12/15/2020 12:18:26 PM

There are no applied moments at both ends. This indicates your M diagram should start and end at zero. If it does not happen like your solution here, that usually means reaction forces or V diagram is incorrect.

XY analysis



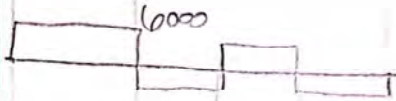
$$A' = C' = 2000 \text{ N}$$

$$\sum M_A = F_{Bc} \times 1.25 - F_{Db} \times 1.375 + A' \times 1.75 - F_{Db} \times 1.25$$

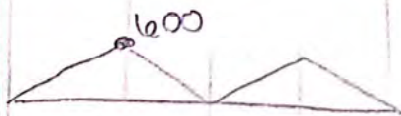
$$C' \times 1.75 - F_{Db} \times 1.25$$

$$E' = 47.65 \text{ N}$$

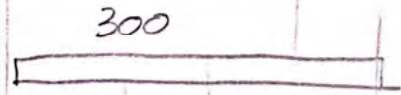
V
(N)



M
(N.m)



T
(N.m)



(C) XY analysis $M_{cr} = 279.2 \text{ N.m}$

XY analysis $M_{et} = 600 \text{ N.m}$

are critical locations



 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:19:00 PM
Due to error in the problem, students with adequate effort gets full credit +5

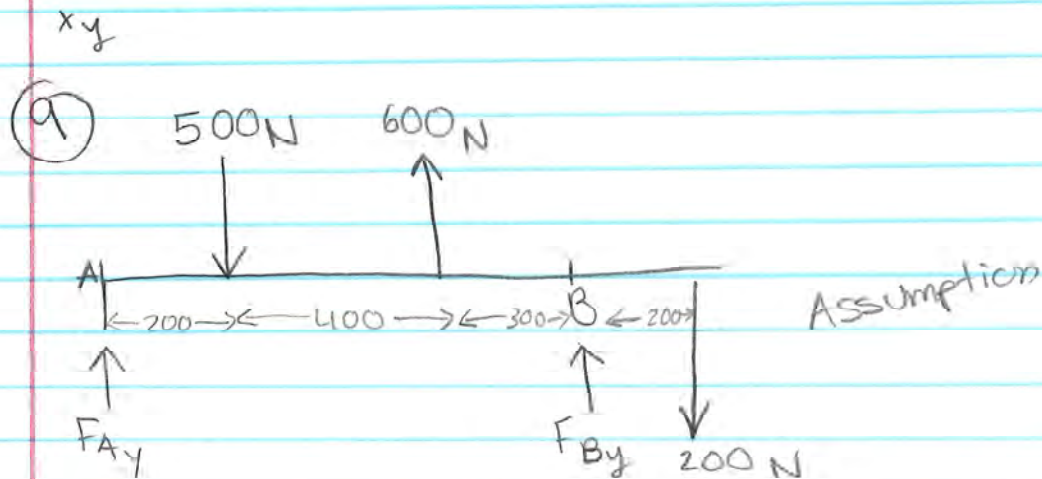
Average

① Given: Constant speed
3 vertical loadings

A + B mounted against sharp
shoulder fillet.

$T = 200 \text{ N}\cdot\text{m}$ all shaft

Material AISI 1030 CD steel $\rightarrow 520 \text{ MPa}$ S_{ut}
 $n_f = 2$



$$\sum F_y = 0$$

$$F_{Ay} - 500 \text{ N} + 600 + F_{By} - 200 \text{ N} = 0$$

$$F_{Ay} = 500 - 600 - F_{By} + 200$$

$$F_{Ay} = -F_{By} + 100$$

$$\sum M_A = 0$$

$$-500(200) + 600(600) + F_{By}(900) - 200(1100) = 0$$

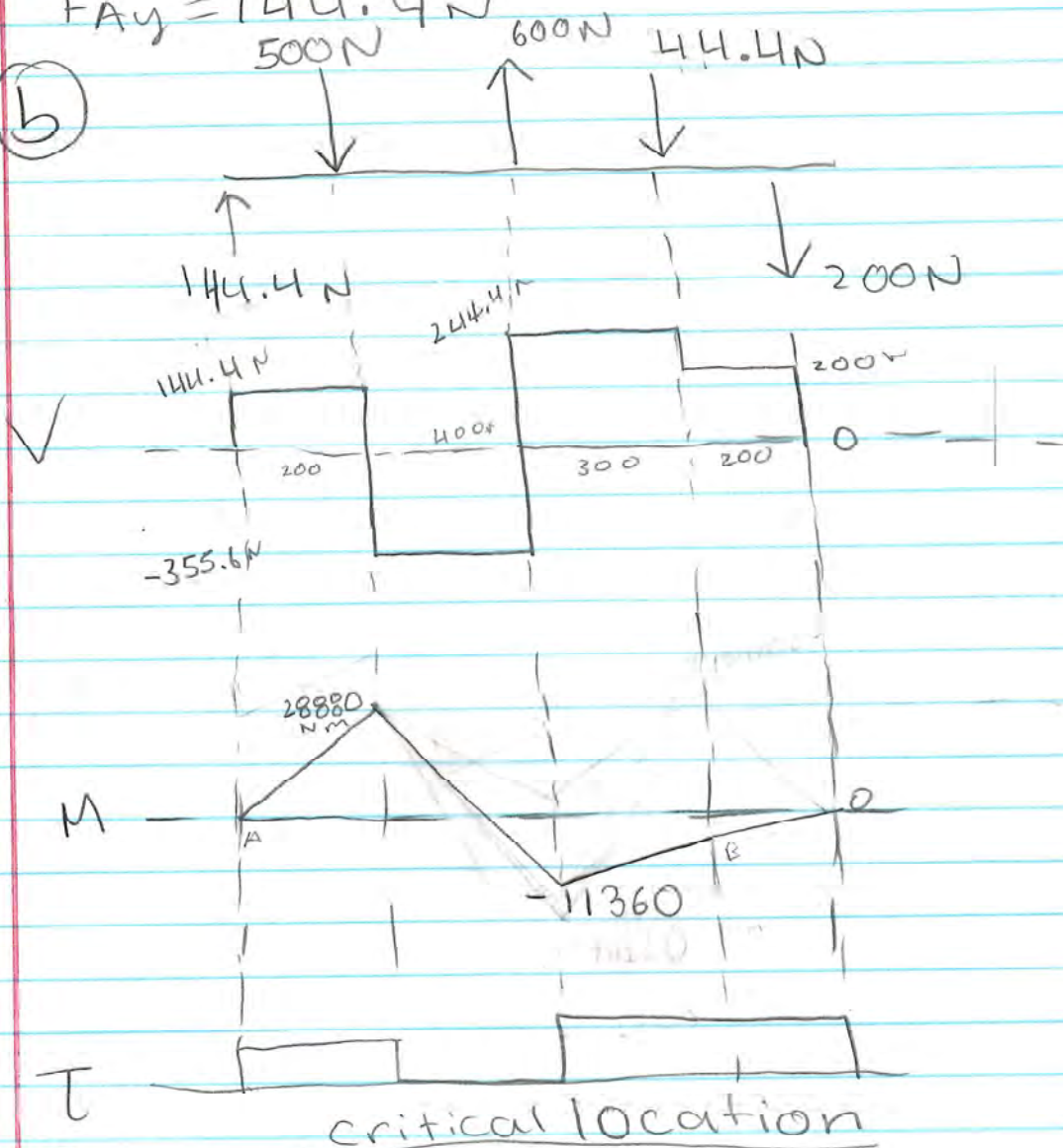
$$F_{By} = \frac{200(1100) + 500(200) - 600(600)}{900}$$

$$F_{By} = -44.4 \text{ N}$$

$$F_{Ay} = -(-44.4) + 100$$

$$F_{Ay} = 144.4 \text{ N}$$

(b)



(c)

(a)

500 N + 200 m

(d)

$$S_{ut} = 520 \text{ mpa}$$

$$520 < 1400 \text{ mpa}$$

$$S'_e = 0.5(520) \text{ mpa}$$

$$S'_e = 260$$

$$K_a = a S_{ut}^b$$

$$K_b =$$

$$S_e = K_a K_b K_c S'_e$$

$$d = \left[\frac{16n}{\pi} \left(\frac{A}{S_e} + \frac{B}{S_{ut}} \right) \right]^{\frac{1}{3}}$$

$$A = \sqrt{4(K_f M_a)^2 + 3(K_{fs} T_a)^2}$$

$$B = \sqrt{4(K_f M_m)^2 + 3(K_{fs} T_m)^2}$$

$$K_f = 1 + q(K_t - 1)$$

$$q =$$

$$K_t =$$

$$\sigma'_a = (\sigma_a^2 + 3T_a^2)^{\frac{1}{2}} = \left[\left(\frac{32 K_f M_a}{\pi d^3} \right)^2 + 3 \left(\frac{16 K_{fs} T_a}{\pi d^3} \right)^2 \right]^{\frac{1}{2}}$$

$$\sigma'_m = (\sigma_m^2 + 3T_m^2)^{\frac{1}{2}} = \left[\left(\frac{32 K_f M_m}{\pi d^3} \right)^2 + 3 \left(\frac{16 K_{fs} T_m}{\pi d^3} \right)^2 \right]^{\frac{1}{2}}$$

$$\sigma_a = \frac{M_a C}{I} K_f$$

$$T_a = K_{fs} \frac{T_{ar}}{J}$$

$$\sigma_m = \frac{M_m C}{I}$$

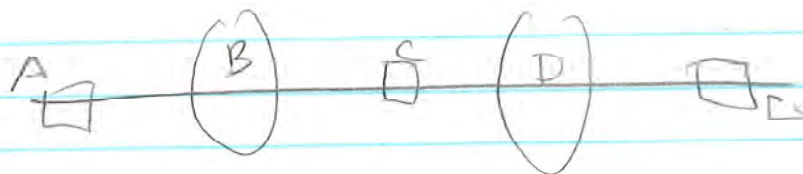
$$T_m = K_{fs} \frac{T_{mr}}{J}$$

Summary of Comments on Average.pdf

Page: 3

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:20:47 PM
The unit for M diagram should be N-mm not N-m. part e, You could assume a size diameter 0.85.
for part e, you can get the corresponding k_t and k_s from Table 7-1. Part f, you can use formula 7-8. part g missing.

2



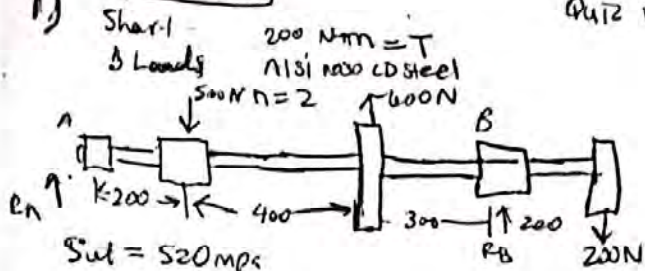
20

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:21:25 PM
Due to error in the problem, students with adequate effort gets full credit +5

Below Average

Question 1)

Quiz Machine 2 Zaidy Melamzhi



$$S_{ut} = 520 \text{ MPa}$$

$$S_y = 440 \text{ MPa}$$

$$\sum M_A = 0$$

$$R_A + 500 + 600 + R_B - 200 = 0$$

$$-200 + 600 = R_A + R_B$$

$$M = F \cdot D \quad -100 = R_A + R_B$$

$$M_A =$$

$$x 200 \cdot 500$$

$$-10000 \text{ N}\cdot\text{m}$$

$$600 \times 400$$

$$24000$$

Summary of Comments on new doc 2020-10-28 09.14.38

Page: 1



Number: 1

Author: japark

Subject: Sticky Note

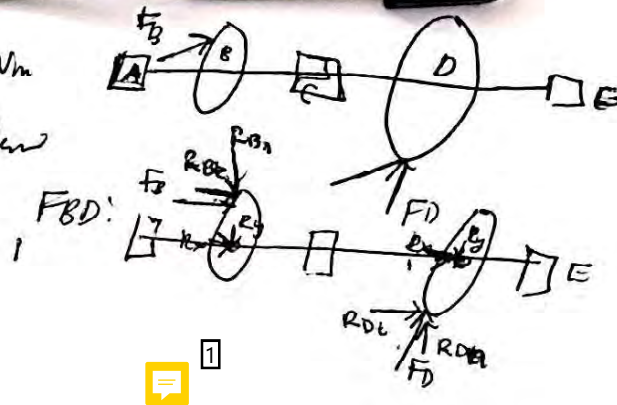
Date: 12/15/2020 12:22:34 PM

Partial credit +3

Question 2) 2 Spur gear $T = 340 \text{ Nm}$

a) No you can not Analyse on single plane

b) FBD & Force $\rightarrow$



 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:22:40 PM
Due to error in the problem, students with adequate effort gets full credit +5

MACHINE DESIGN II
FALL 2020

TITLE OF ASSIGNMENT: QUIZ 4

TOPICS COVERED IN QUIZ 4

1. Brakes
 - a. Internal Expanding Brake
 - b. External Contracting Brake
2. Rolling Contact Bearing

Quiz 4

⚠ This is a preview of the published version of the quiz

Started: Dec 15 at 2:37pm

Quiz Instructions

You have until 9: 15 AM to **complete and submit your work.**

If you start right at 8:05 AM, you will have a total of 70 minutes. Use your time wisely.

This quiz has two problems.

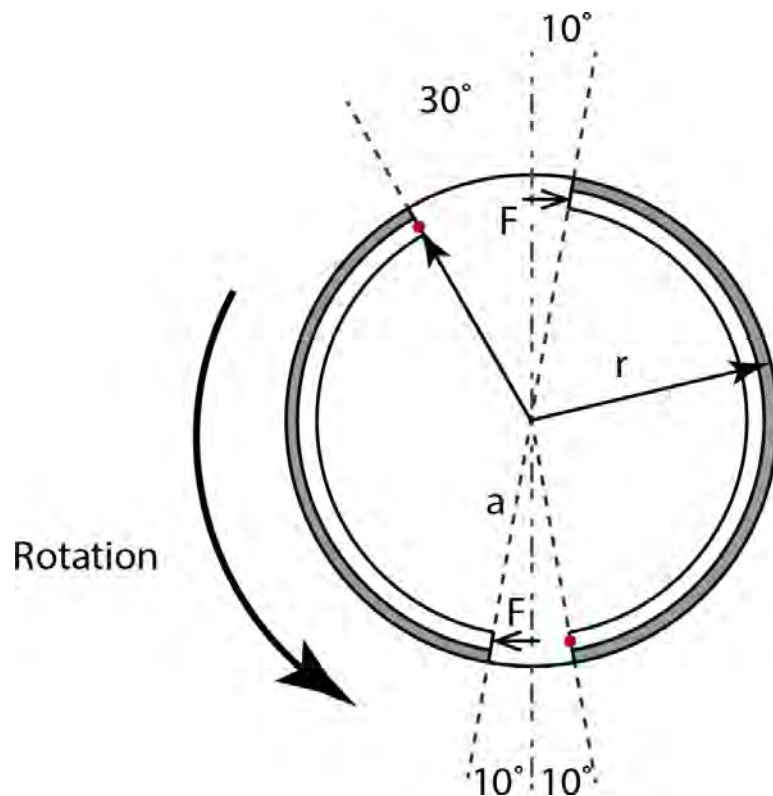
If you believe any information is missing, make a reasonable assumption, and state why you are making that assumption.

Do not misuse the internet (e.g., asking solutions on Chegg, googling problem solutions, etc.) They are considered academic misconduct.

Question 1

10 pts

An internal rim-type brake having $r=8$ in, and $a=7.5$ in has two shoes with 2 in width. Both shoes are actuated by a force (F) of 600 lbf. The friction material has a mean coefficient of friction of 0.3. The drum rotates counterclockwise. The red dots represent the hinge pin.



- Find relevant angles (θ_1 , θ_2 , and θ_a) for each shoe.
- Draw FBD of each shoe.
- Indicate whether each shoe is self-energizing or not.
- Calculate the p_a of both shoes.
- Estimate the braking torque generated by each shoe and find the total braking torque.

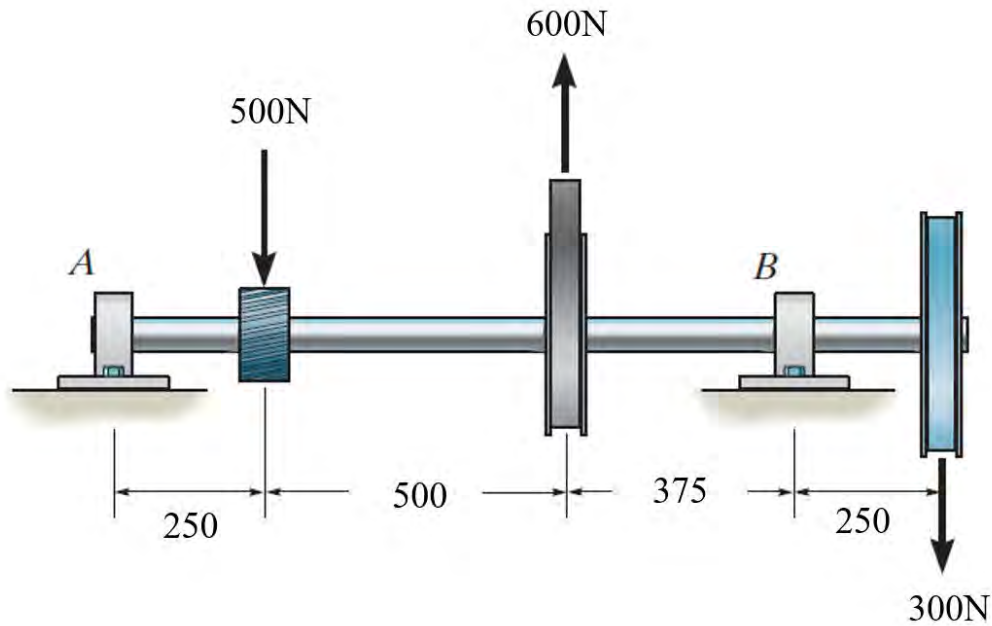
Upload

Question 2

10 pts

A shaft is loaded with three vertical loadings as shown from three different components that are rotating at a constant speed of 1000 rpm with the shaft using end mill keyseats. The bearings at A and B are mounted against sharp shoulder fillet. The whole mechanism is driven by a motor (not shown) which results in 150 N-m of

torque in the entire shaft. All lengths shown in the figure are in mm. The bearings at A and B should survive 5000 hr of operating time.



- Compute the bearing reactions at A & B.
- What is the catalog load rating for each bearing?

Upload

Choose a File

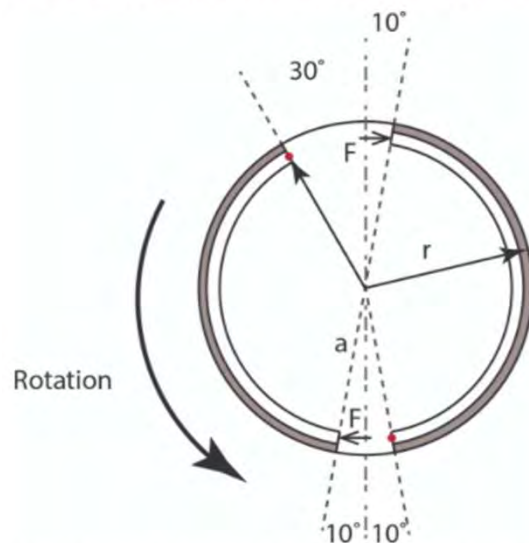
Not saved

Submit Quiz

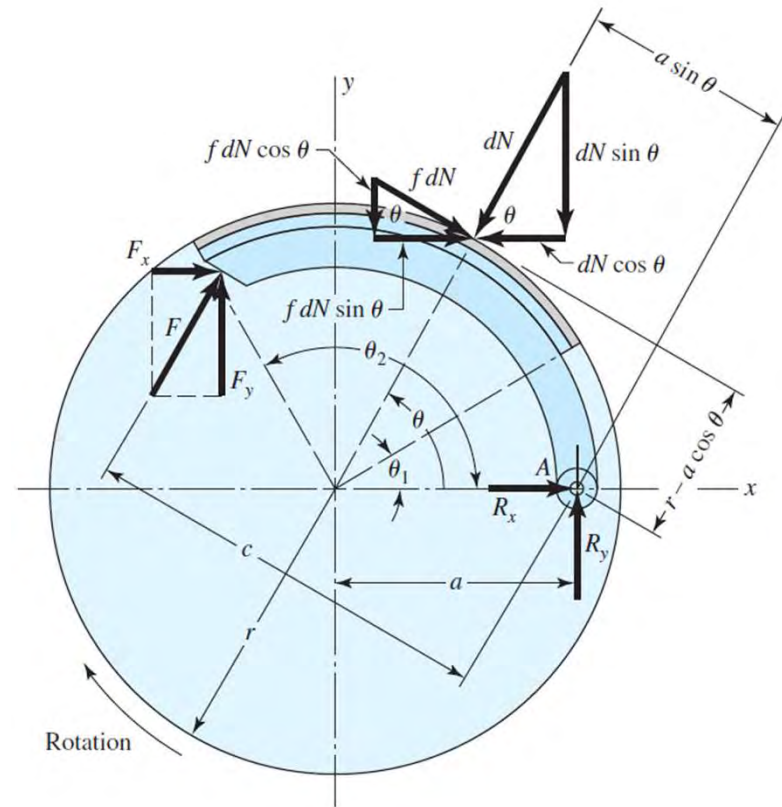
Quiz 4 problem 1



An internal rim-type brake having $r=8$ in, and $a=7.5$ in has two shoes with 2 in width. Both shoes are actuated by a force (F) of 600 lbf. The friction material has a mean coefficient of friction of 0.3. The drum rotates counterclockwise. The red dots represent the hinge pin.

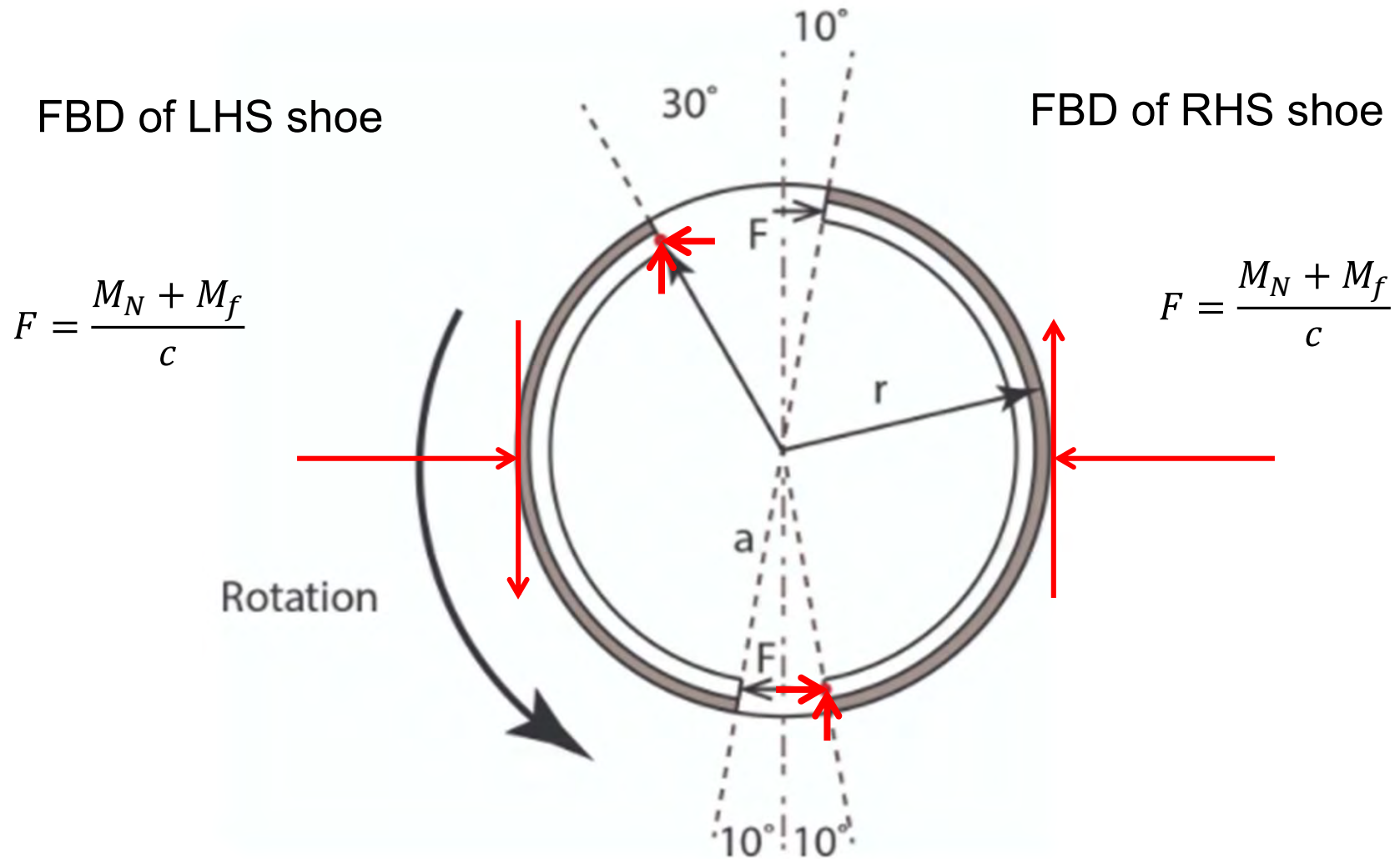


- Find relevant angles (θ_1 , θ_2 , and θ_a) for each shoe.
- Draw FBD of each shoe.
- Indicate whether each shoe is self-energizing or not.
- Calculate the p_a of both shoes.
- Estimate the braking torque generated by each shoe and find the total braking torque.



	LHS	RHS
θ_1	0°	0°
θ_2	140°	160°
θ_p	90°	90°

Quiz 4 problem 1

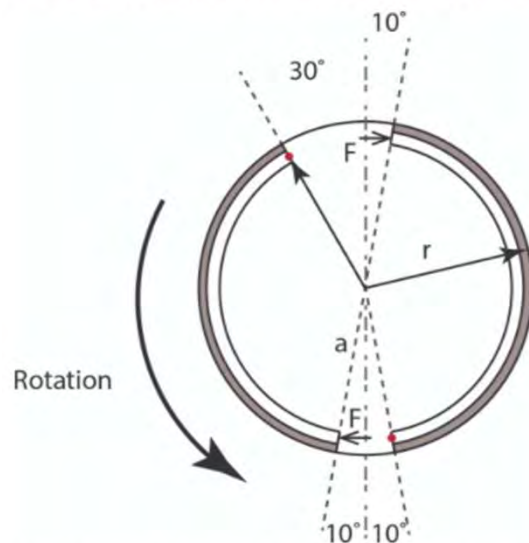


Both sides are NOT self-energizing

Quiz 4 problem 1



An internal rim-type brake having $r=8$ in, and $a=7.5$ in has two shoes with 2 in width. Both shoes are actuated by a force (F) of 600 lbf. The friction material has a mean coefficient of friction of 0.3. The drum rotates counterclockwise. The red dots represent the hinge pin.



- Find relevant angles (θ_1 , θ_2 , and θ_a) for each shoe.
- Draw FBD of each shoe.
- Indicate whether each shoe is self-energizing or not.
- Calculate the p_a of both shoes.
- Estimate the braking torque generated by each shoe and find the total braking torque.

	LHS	RHS
θ_1	0°	0°
θ_2	140°	160°
θ_p	90°	90°

$$r = 6\text{ in}, b = 2\text{ in}, f = 0.3$$

$$M_N = \frac{p_a b r a}{\sin \theta_a} \int_{\theta_1}^{\theta_2} \sin^2 \theta d\theta$$

$$M_f = \frac{f p_a b r}{\sin \theta_a} \int_{\theta_1}^{\theta_2} \sin \theta (r - a \cos \theta) d\theta$$

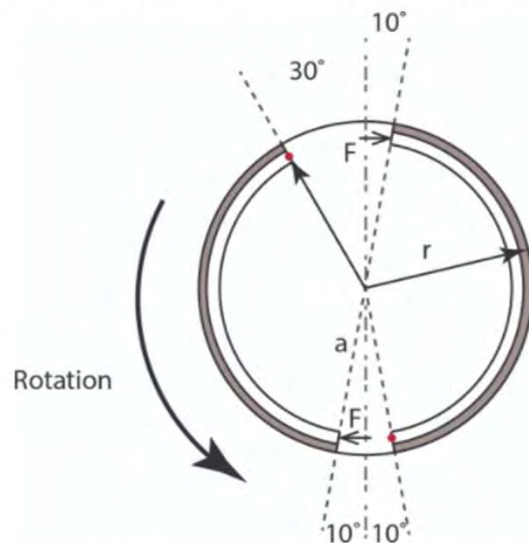
$$F = \frac{M_N + M_f}{c}$$

You will get different p_a for each shoe because shoe coverage angles are different.

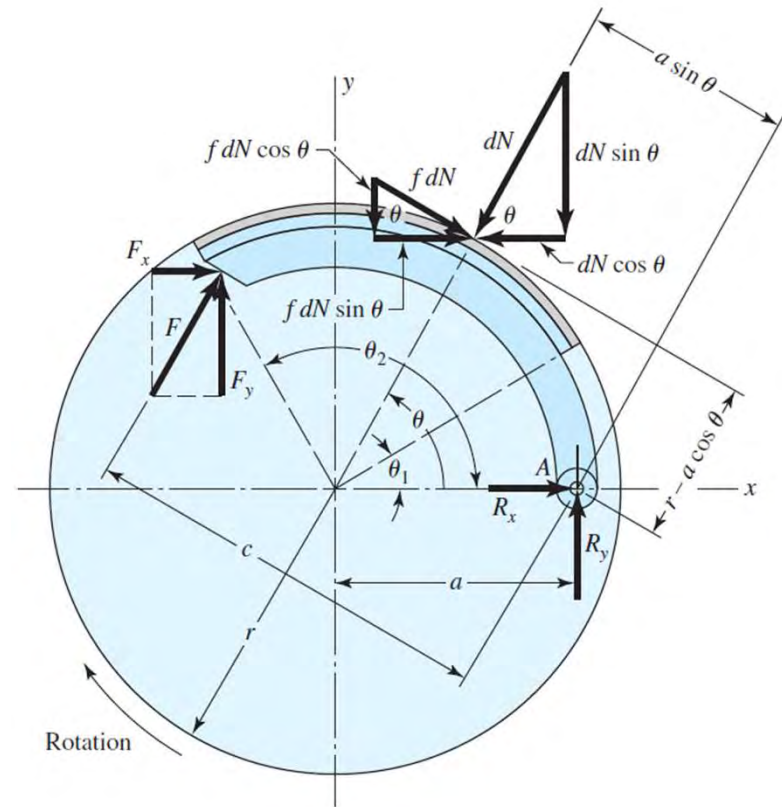
Quiz 4 problem 1



An internal rim-type brake having $r=8$ in, and $a=7.5$ in has two shoes with 2 in width. Both shoes are actuated by a force (F) of 600 lbf. The friction material has a mean coefficient of friction of 0.3. The drum rotates counterclockwise. The red dots represent the hinge pin.



- Find relevant angles (θ_1 , θ_2 , and θ_a) for each shoe.
- Draw FBD of each shoe.
- Indicate whether each shoe is self-energizing or not.
- Calculate the p_a of both shoes.
- Estimate the braking torque generated by each shoe and find the total braking torque.

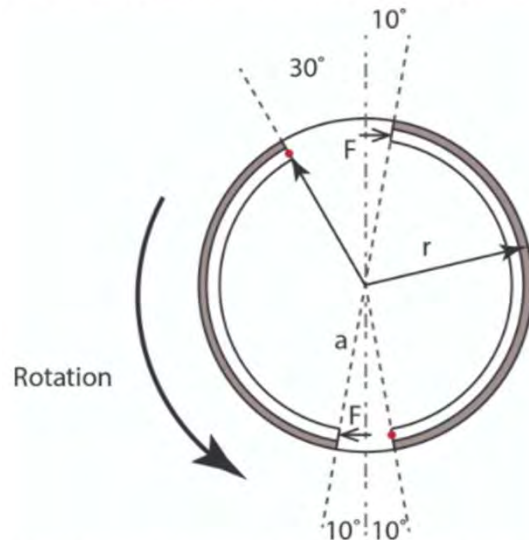


How do we get the c for each shoe?

Quiz 4 problem 1



An internal rim-type brake having $r=8$ in, and $a=7.5$ in has two shoes with 2 in width. Both shoes are actuated by a force (F) of 600 lbf. The friction material has a mean coefficient of friction of 0.3. The drum rotates counterclockwise. The red dots represent the hinge pin.



- Find relevant angles (θ_1 , θ_2 , and θ_a) for each shoe.
- Draw FBD of each shoe.
- Indicate whether each shoe is self-energizing or not.
- Calculate the p_a of both shoes.
- Estimate the braking torque generated by each shoe and find the total braking torque.

$$T = \frac{f p_a b r^2 (\cos \theta_1 - \cos \theta_2)}{\sin \theta_a}$$

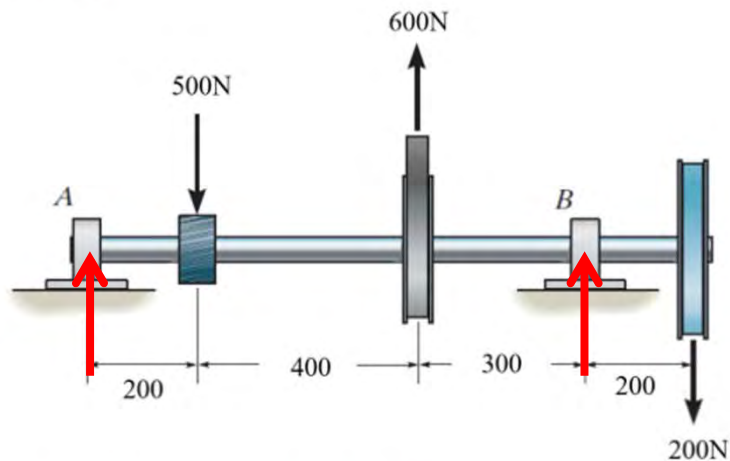
p_a values are different between LHS and RHS shoes.

You should calculate the torque on each side separately then add to find total torque!

Quiz 4 problem 2



A shaft is loaded with three vertical loadings as shown from three different components that are rotating at a constant speed of 850 rpm with the shaft using end mill keyseats. The bearings at A and B are mounted against sharp shoulder fillet. The whole mechanism is driven by a motor (not shown) which results in 1250 N-m of torque in the entire shaft. All lengths shown in the figure are in mm. The bearings at A and B should survive 30000 hr of operating time.



- Compute the bearing reactions at A & B.
- What is the catalog load rating for each bearing?

- We had this exact configuration in earlier quiz!
- We use moment balance
 - $B_y = -44N, A_y = 144N$
- $C_{10} = F_R = F_D \left(\frac{\mathcal{L}_D n_D 60}{\mathcal{L}_R n_R 60} \right)^{\frac{1}{a}}$
- $\mathcal{L}_D = 30000 \text{ hr}$
- $n_D = 850 \text{ rpm}$
- $\mathcal{L}_R n_R 60 = L_R = 10^6 \text{ rev}$
- $a = 3 \text{ or } \frac{10}{3}$

Above Average

Merrell Exam one

① Data

$$r = 8.5$$

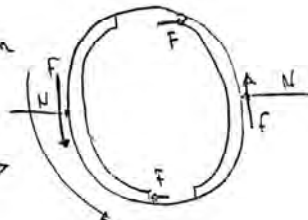
$$a = 8 \text{ in}$$

$$b = 2.5$$

$$\bar{F} = 50 \text{ lbf}$$

$$f = 0.3$$

Rotation



a) $Q_1 = 0$

$$Q_2 = 90$$

$$Q_3 = 90$$

b)

c) There is no self-energizing because none of the friction forces is going in the same direction as the shoe.

d) 1st shoe $F_c - M_p = M_k$

$$F = \frac{M_k + M_p}{f}$$

$$M_p = \frac{f P_c b r}{\sin \theta_c} \int_{\theta_1}^{\theta_2} \sin(r - a \cos \theta) d\theta$$

$$M_p = \frac{0.3 \cdot P_c \cdot 2.5 \cdot 8.5}{\sin 90} \cdot \left[\int_0^{90} \sin(8.5 - 8 \cos \theta) d\theta \right]$$

$$= 6.375 \cdot P_c \cdot \left[(0.95 \cdot \cos \theta)_0^{90} - \left(\frac{1}{4} \cos 2\theta \right)_0^{90} \right]$$

$$M_P = 1.35 \cdot P_0$$

$$\begin{aligned} M_H &= \frac{P_0 b r a}{\sin \theta_1} \int_{\theta_1}^{\theta_2} \sin^2 \theta d\theta \\ &= \frac{P_0 \cdot 2.5 \cdot 8 \cdot 5 \cdot 8}{\sin 90} \int_0^{90} \sin^2 \theta d\theta \\ &= 110 P_0 \left[\frac{\theta}{2} - \frac{1}{4} \sin 2\theta \right]_0^{90} \\ &= 100.20 P_0 \end{aligned}$$

$$F = \frac{M_P + M_H}{c} \Rightarrow 300 = \frac{7.35 P_0 + 100.20 P_0}{0.98}$$

$$c = 2r \sin \theta_1$$

$$c = 2 \cdot 8 \cdot \cos 10 = 0.98$$

$$P_0 = 4.57 \text{ psi}$$

2nd floor will be the same since $F = \frac{M_P + M_H}{c}$

$$P_0 = 4.57$$

$$\begin{aligned} d) T_R &= \frac{P_0 b r^2 (\cos \theta_1 - \cos \theta_2)}{\sin \theta_1} = \frac{0.3 \cdot 4.57 \cdot 2.5 \cdot 8^2 (\cos 0 - \cos 90)}{\sin 90} \\ &= 500 \text{ lbf. ft.} \end{aligned}$$

$$T_L = \frac{P_0 b r^2 (\cos \theta_1 - \cos \theta_2)}{\sin \theta_1} = 500 \text{ lbf. ft.}$$

$$T_{\text{Total}} = 1000 \text{ lbf. ft.}$$



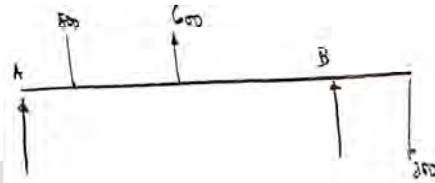
Summary of Comments on quiz 4

Page: 2

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:24:39 PM
FBDs are incomplete. Hinge pin reactions are missing.

 Author: japark Subject: Sticky Note Date: 12/15/2020 12:24:48 PM
9/10

② $n_d = 800 \text{ rpm}$
 $T = 150 \text{ N.m}$
 $L = 10000 \text{ hr}$



g) $\sum M_A = 0$

$$-500 \cdot \frac{250}{10^3} + 500 \cdot \frac{400}{10^3} + \frac{900 \cdot R_B}{10^3} - 200 \cdot \frac{1100}{10^3} = 0$$

$$R_B = \frac{100 - 240 + 210}{0.9} = 88.88$$

$\sum F_y = 0$

$$R_A - 500 + 500 + 88.88 - 200 = 0$$

$$R_A = 111.2 \text{ N}$$

$$C_A = \bar{F}_R \cdot \bar{F}_D \left(\frac{L_D}{L_R} \right)^{\frac{1}{a}} = 111.2 \cdot \left(\frac{10000 \text{ hr} \cdot 800 \text{ rpm} \cdot 60}{10^6} \right)^{\frac{1}{3}}$$

$$C_B = \bar{F}_R \cdot \bar{F}_D \left(\frac{L_D}{L_R} \right)^{\frac{1}{a}} = 88.88 \cdot \left(\frac{10000 \text{ hr} \cdot 800 \text{ rpm} \cdot 60}{10^6} \right)^{\frac{1}{3}}$$

$$C_A = 3211 \text{ lb}$$

$$C_C = 4001 \text{ lb}$$



1



Number: 1

Author: japark

Subject: Sticky Note

Date: 12/15/2020 12:25:01 PM

10/10 Great!

Average

Asher Carson

1.) $r = 8.5 \text{ in}$

$a = 4 \text{ in}$

$b = 2.5 \text{ in}$

$f = 0.3$

Right Shoe

a.) $\theta_n = 90^\circ$

$\theta_1 = 0^\circ$

$\theta_2 = 140^\circ - 10^\circ - \tan^{-1}\left(\frac{y}{x}\right)$

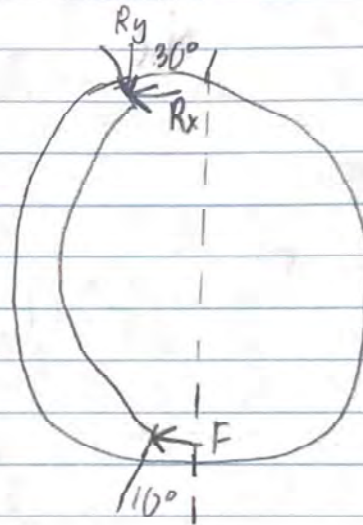
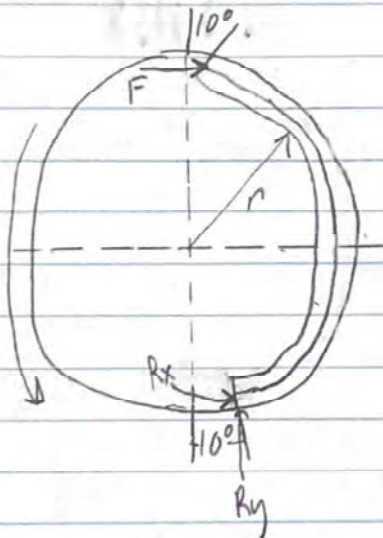
Left Shoe

$\theta_n = 90^\circ$

$\theta_1 = 0^\circ$

$\theta_2 = 140^\circ - 30^\circ - \tan^{-1}\left(\frac{y}{x}\right)$

b.)



c.)



1

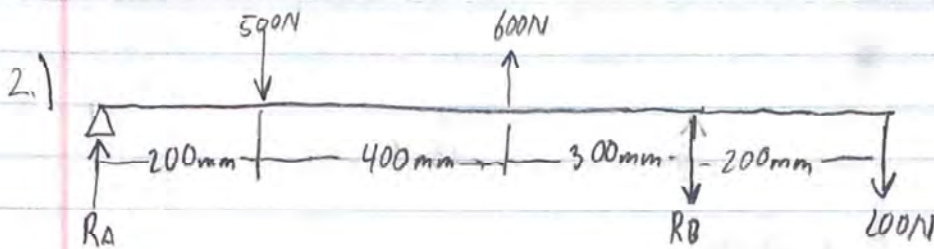
Summary of Comments on A9R776r5x_1rhz8hr_8d0.tmp

Page: 1

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:26:29 PM

You do not need tangent calculation when computing θ_2 . The concept is in fact not that difficult. Please make sure you grasp it before the final exam. Let me know if you need my help.

3/10



$$\sum M_A = 0$$

$$0 = -500\text{N}(200\text{mm}) + 600\text{N}(600\text{mm}) + R_B(900\text{mm}) - 200\text{N}(1100\text{mm})$$

$$0 = -100000\text{N}\cdot\text{mm} + 360000\text{N}\cdot\text{mm} + R_B(900\text{mm}) - 220000\text{N}\cdot\text{mm}$$

$$0 = 40000\text{N}\cdot\text{mm} + R_B(900\text{mm})$$

$$\frac{-40000\text{N}\cdot\text{mm}}{900\text{mm}} = \frac{R_B(900\text{mm})}{900\text{mm}}$$

$$R_B = -44.4\text{N}$$

$$R_B = 44.4\text{N} \downarrow$$

$$+\uparrow \sum F_y = 0$$

$$0 = R_A - 500\text{N} + 600\text{N} - 44.4\text{N} - 200\text{N}$$

$$R_A = 500\text{N} - 600\text{N} + 44.4\text{N} + 200\text{N}$$

$$R_A = 144\text{N}$$

$L_0 = 1000\text{hr}$ $n_0 = 400\text{rpm}$ $a = 3, \text{ball bearing}$ $F_{DA} = 144\text{N}$ $F_{DB} = 44.4\text{N}$ $L_R = 10^6\text{rev}$

Bearing A

$$C_{10} = F_D \left(\frac{L_0 n_0 60}{L_R} \right)^{1/a}$$

$$C_{10} = 144\text{N} \left(\frac{1000\text{hr} \cdot 400\text{rpm} \cdot 60}{10^6} \right)^{1/3}$$

$$C_{10} = 523.33\text{N}$$

Bearing B

$$C_{10} = 44.4\text{N} \left(\frac{1000\text{hr} \cdot 400\text{rpm} \cdot 60}{10^6} \right)^{1/3}$$

$$C_{10} = 161.36\text{N}$$



Below Average

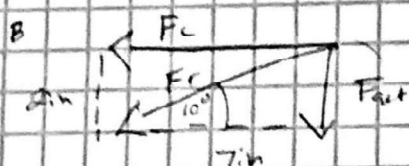
1

$$\begin{aligned} r &= 8.5 \text{ in} & F &= 500 \text{ lbf} \\ a &= 8 \text{ in} & \mu &= 0.3 \text{ new} \\ W &= 2.5 \text{ in} \end{aligned}$$

$$\begin{aligned} \theta_1 &= 10^\circ + \tan^{-1} \frac{a}{r} = 4.05^\circ \\ \theta_2 &= 180^\circ - 30^\circ + \tan^{-1} \left(\frac{a}{r} \right) = 134^\circ \\ \theta_3 &= 90^\circ & a &= \sqrt{(2)^2 + (7)^2} = 7.28 \end{aligned}$$

$$M_r = \frac{F_R \cdot r}{\sin \theta_3} \int_{\theta_1}^{\theta_2} \sin \theta (1 - \cos \theta) d\theta$$

$$M_r = \frac{(0.3)(500)(8)(-1)}{\sin 90^\circ} \int_{4^\circ}^{134^\circ} \sin \theta (7 - 7.28 \cos \theta) d\theta$$



C Both sides are self-energizing

$$F_C = \frac{M_N + M_r}{C_R}$$

1

2

Summary of Comments on Nov 16, Doc 1.pdf

Page: 1

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:28:01 PM

Tangent is not necessary when computing the angles. Both sides are NOT self energizing. It looks like you were not fully prepared. Please make sure you grasp the concept before the final!

5/10

 Number: 2 Author: japark Subject: Sticky Note Date: 12/15/2020 12:28:10 PM

Solution to P2 is missing -10

V. HOMEWORK

**MACHINE DESIGN II
FALL 2020**

TITLE OF ASSIGNMENT: HOMEWORK 1

TOPICS COVERED IN HOMEWORK 1

1. Gears – General (Chapter 13)

Grade:

Name:

This assignment is due at 10 AM on September 16th. Complete the following problems from Shigley's Mechanical Engineering Design – 10th edition.

1. Problem 13-3
2. Problem 13-7
3. Problem 13-10
4. Problem 13-15
5. Problem 13-16
6. Problem 13-22
7. Problem 13-24
8. Problem 13-33

Homework requirement

- Print this page and use it as the cover.
- The submission should be each student's own work.
- The same day late submission will get a 10% penalty.
- Once the solution is posted, no more submission will be accepted.
- Write legibly. No credit will be given if the work is not readable.
- Take advantage of office hours.
 - Tuesdays & Thursdays 1 PM ~ 3 PM (tentative, may change in the week of June 1st)
 - Email me: japark@pvamu.edu to request a Zoom meeting if you cannot make it to the regular office hour due to any university excused reasons.

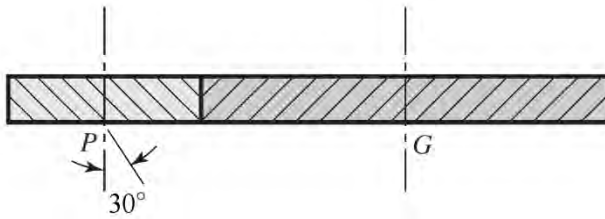
Problem 13-3

$$N_G = 16(4) = 64 \text{ teeth} \quad \text{Ans.}$$

$$d_G = N_G m = 64(6) = 384 \text{ mm} \quad \text{Ans.}$$

$$d_P = N_P m = 16(6) = 96 \text{ mm} \quad \text{Ans.}$$

$$C = (384 + 96) / 2 = 240 \text{ mm} \quad \text{Ans.}$$

Problem 13-7

$$N_P = 19 \text{ teeth}, N_G = 57 \text{ teeth}, \phi_n = 20^\circ, m_n = 2.5 \text{ mm}$$

$$(a) \quad p_n = \pi m_n = \pi(2.5) = 7.854 \text{ mm} \quad \text{Ans.}$$

$$p_t = \frac{p_n}{\cos \psi} = \frac{7.854}{\cos 30^\circ} = 9.069 \text{ mm} \quad \text{Ans.}$$

$$p_x = \frac{p_t}{\tan \psi} = \frac{9.069}{\tan 30^\circ} = 15.71 \text{ mm} \quad \text{Ans.}$$

$$(b) \quad m_t = \frac{m_n}{\cos \psi} = \frac{2.5}{\cos 30^\circ} = 2.887 \text{ mm} \quad \text{Ans.}$$

$$\phi_t = \tan^{-1} \left(\frac{\tan 20^\circ}{\cos 30^\circ} \right) = 22.80^\circ \quad \text{Ans.}$$

$$(c) \quad a = m_n = 2.5 \text{ mm} \quad \text{Ans.}$$

$$b = 1.25 m_n = 1.25(2.5) = 3.125 \text{ mm} \quad \text{Ans.}$$

$$d_P = \frac{N}{P_t} = N m_t = 19(2.887) = 54.85 \text{ mm} \quad \text{Ans.}$$

$$d_G = 57(2.887) = 164.6 \text{ mm} \quad \text{Ans.}$$

Problem 13-10

(a) The smallest pinion tooth count that will run with itself is found from Eq. (13-10).

$$\begin{aligned}
 N_p &\geq \frac{2k}{3\sin^2 \phi} \left(1 + \sqrt{1 + 3\sin^2 \phi} \right) \\
 &\geq \frac{2(1)}{3\sin^2 20^\circ} \left(1 + \sqrt{1 + 3\sin^2 20^\circ} \right) \\
 &\geq 12.32 \rightarrow 13 \text{ teeth } \textit{Ans.}
 \end{aligned}$$

(b) The smallest pinion that will mesh with a gear ratio of $m_G = 2.5$, from Eq. (13-11) is

$$\begin{aligned}
 N_p &\geq \frac{2k}{(1+2m)\sin^2 \phi} \left(m + \sqrt{m^2 + (1+2m)\sin^2 \phi} \right) \\
 &\geq \frac{2(1)}{[1+2(2.5)]\sin^2 20^\circ} \left\{ 2.5 + \sqrt{2.5^2 + [1+2(2.5)]\sin^2 20^\circ} \right\} \\
 &\geq 14.64 \rightarrow 15 \text{ teeth } \textit{Ans.}
 \end{aligned}$$

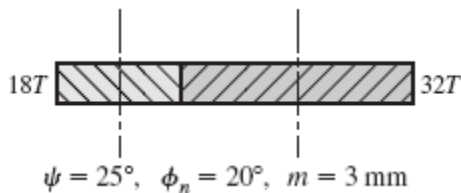
The largest gear-tooth count possible to mesh with this pinion, from Eq. (13-12) is

$$\begin{aligned}
 N_G &\leq \frac{N_p^2 \sin^2 \phi - 4k^2}{4k - 2N_p \sin^2 \phi} \\
 &\leq \frac{15^2 \sin^2 20^\circ - 4(1)^2}{4(1) - 2(15)\sin^2 20^\circ} \\
 &\leq 45.49 \rightarrow 45 \text{ teeth } \textit{Ans.}
 \end{aligned}$$

(c) The smallest pinion that will mesh with a rack, from Eq. (13-13),

$$\begin{aligned}
 N_p &\geq \frac{2k}{\sin^2 \phi} = \frac{2(1)}{\sin^2 20^\circ} \\
 &\geq 17.097 \rightarrow 18 \text{ teeth } \textit{Ans.}
 \end{aligned}$$

Problem 13-15



(a) Eq. (13-3): $p_n = \pi m_n = 3\pi \text{ mm}$ *Ans.*

Eq. (13-16): $p_t = p_n / \cos \psi = 3\pi / \cos 25^\circ = 10.40 \text{ mm}$ *Ans.*

$$\text{Eq. (13-17): } p_x = p_t / \tan \psi = 10.40 / \tan 25^\circ = 22.30 \text{ mm} \quad \text{Ans.}$$

$$\text{(b) Eq. (13-3): } m_t = p_t / \pi = 10.40 / \pi = 3.310 \text{ mm} \quad \text{Ans.}$$

$$\text{Eq. (13-19): } \phi_t = \tan^{-1} \frac{\tan \phi_n}{\cos \psi} = \tan^{-1} \frac{\tan 20^\circ}{\cos 25^\circ} = 21.88^\circ \quad \text{Ans.}$$

$$\text{(c) Eq. (13-2): } d_p = m_t N_p = 3.310 (18) = 59.58 \text{ mm} \quad \text{Ans.}$$

$$\text{Eq. (13-2): } d_G = m_t N_G = 3.310 (32) = 105.92 \text{ mm} \quad \text{Ans.}$$

Problem 13-16

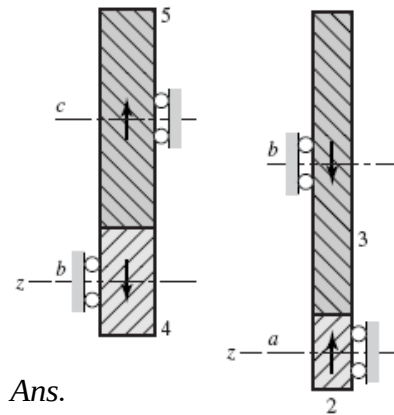
(a) Sketches of the figures are shown to determine the axial forces by inspection.

The axial force of gear 2 on shaft *a* is in the negative *z*-direction. The axial force of gear 3 on shaft *b* is in the positive *z*-direction. *Ans.*

The axial force of gear 4 on shaft *b* is in the positive *z*-direction. The axial force of gear 5 on shaft *c* is in the negative *z*-direction. *Ans.*

$$\text{(b) } n_c = n_5 = \frac{12}{48} \left(\frac{16}{36} \right) (700) = +77.78 \text{ rev/min ccw} \quad \text{Ans.}$$

$$\begin{aligned} \text{(c) } d_{p2} &= 12 / (12 \cos 30^\circ) = 1.155 \text{ in} \\ d_{G3} &= 48 / (12 \cos 30^\circ) = 4.619 \text{ in} \\ C_{ab} &= \frac{1.155 + 4.619}{2} = 2.887 \text{ in} \quad \text{Ans.} \\ d_{p4} &= 16 / (8 \cos 25^\circ) = 2.207 \text{ in} \\ d_{G5} &= 36 / (8 \cos 25^\circ) = 4.965 \text{ in} \\ C_{bc} &= 3.586 \text{ in} \quad \text{Ans.} \end{aligned}$$



Problem 13-22

Applying Eq. (13-30), $e = (N_2 / N_3) (N_4 / N_5) = 30$. For an exact ratio, we will choose to factor the train value into integers, such that

$$N_2 / N_3 = 6 \quad (1)$$

$$N_4 / N_5 = 5 \quad (2)$$

Assuming a constant diametral pitch in both stages, the geometry condition to satisfy the in-line requirement of the compound reverted configuration is

$$N_2 + N_3 = N_4 + N_5 \quad (3)$$

With three equations and four unknowns, one free choice is available. It is necessary that all of the unknowns be integers. We will use a normalized approach to find the minimum free choice to guarantee integers; that is, set the smallest gear of the largest stage to unity, thus $N_3 = 1$. From (1), $N_2 = 6$. From (3),

$$N_2 + N_3 = 6 + 1 = 7 = N_4 + N_5$$

Substituting $N_4 = 5 N_5$ from (2) gives

$$\begin{aligned} 7 &= 5 N_5 + N_5 = 6 N_5 \\ N_5 &= 7 / 6 \end{aligned}$$

To eliminate this fraction, we need to multiply the original free choice by a multiple of 6. In addition, the smallest gear needs to have sufficient teeth to avoid interference. From Eq. (13-11) with $k = 1$, $\phi = 20^\circ$, and $m = 6$, the minimum number of teeth on the pinion to avoid interference is 16. Therefore, the smallest multiple of 6 greater than 16 is 18. Setting $N_3 = 18$ and repeating the solution of equations (1), (2), and (3) yields

$$\begin{aligned} N_2 &= 108 \text{ teeth} \\ N_3 &= 18 \text{ teeth} \\ N_4 &= 105 \text{ teeth} \\ N_5 &= 21 \text{ teeth} \end{aligned} \quad \text{Ans.}$$

Problem 13-24

$H = 25 \text{ hp}$, $\omega_i = 2500 \text{ rev/min}$

Let $\omega_o = 300 \text{ rev/min}$ for minimal gear ratio to minimize gear size.

$$\frac{\omega_o}{\omega_i} = \frac{300}{2500} = \frac{1}{8.333} = \frac{N_2}{N_3} \frac{N_4}{N_5}$$

$$\text{Let } \frac{N_2}{N_3} = \frac{N_4}{N_5} = \sqrt{\frac{1}{8.333}} = \frac{1}{2.887}$$

From Eq. (13-11) with $k = 1$, $\phi = 20^\circ$, and $m = 2.887$, the minimum number of teeth on the pinions to avoid interference is 15.

$$\begin{aligned} \text{Let } N_2 &= N_4 = 15 \text{ teeth} \\ N_3 &= N_5 = 2.887(15) = 43.31 \text{ teeth} \end{aligned}$$

Try $N_3 = N_5 = 43 \text{ teeth}$.

$$\omega_o = \left(\frac{15}{43}\right)\left(\frac{15}{43}\right)(2500) = 304.2$$

Too big. Try $N_3 = N_5 = 44$.

$$\omega_o = \left(\frac{15}{44}\right)\left(\frac{15}{44}\right)(2500) = 290.55 \text{ rev/min}$$

$N_2 = N_4 = 15$ teeth, $N_3 = N_5 = 44$ teeth *Ans.*

Problem 13-33

Given: $m = 12$ mm, $n_P = 1800$ rev/min cw,
 $N_2 = 18T$, $N_3 = 32T$, $N_4 = 18T$, $N_5 = 48T$

Pitch Diameters: $d_2 = 18(12) = 216$ mm, $d_3 = 32(12) = 384$ mm,
 $d_4 = 18(12) = 216$ mm, $d_5 = 48(12) = 576$ mm

Gear 2

From Eq. (13-36),

$$W_t = \frac{60000H}{\pi d n} = \frac{60000(150)}{\pi(216)(1800)} = 7.368 \text{ kN}$$

$$T_{a2} = W_t \left(\frac{d_2}{2}\right) = 7.368 \left(\frac{216}{2}\right) = 795.7 \text{ N}\cdot\text{m}$$

$$W^r = 7.368 \tan 20^\circ = 2.682 \text{ kN}$$

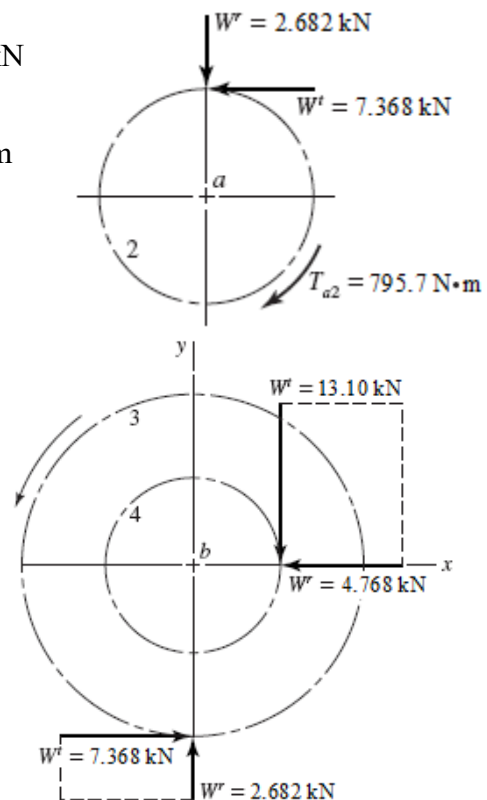
Gears 3 and 4

$$W_t \left(\frac{216}{2}\right) = 7.368 \frac{(384)}{2}$$

$$W_t = 13.10 \text{ kN}$$

$$W^r = 13.10 \tan 20^\circ = 4.768 \text{ kN}$$

Ans.



Above Average

Grade:

Name: Donald Conner

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Summary of Comments on Sep 16, Doc 1.pdf

Page: 1

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:41:26 PM

Graded 13-15 and 13-24. Well organized and easy to follow. Keep it up.

10/10

13.3

$$m = 6 \text{ mm}$$

$$N_p = 16$$

$$n_p/n_g = 4$$

$$N_g = 64 \text{ teeth}$$

$$d_p = 96 \text{ mm}$$

$$C = 240 \text{ mm}$$

$$\frac{n_p}{n_g} = \frac{N_g}{N_p}$$

$$4 = N_g/16$$

$$N_g = 4 \cdot 16$$

$$N_g = 64 \text{ teeth}$$

$$m = d_g/N_g$$

$$6 = d_g/64$$

$$d_g = 384$$

$$d_p = N_p \cdot m$$

$$d_p = 16 \cdot 6$$

$$d_p = 96 \text{ mm}$$

$$C = d_p + d_g/2$$

$$C = 96 + 384/2$$

$$\rightarrow C = 240 \text{ mm}$$

13.7

$$m = 2.5 \text{ mm}$$

$$N_p = 19 \text{ teeth}$$

$$N_g = 57 \text{ teeth}$$

$$\psi = 30^\circ$$

$$\phi = 20^\circ$$

$$p_n = 7.854 \text{ mm}$$

$$p_t = 9.069 \text{ mm}$$

$$p_x = 15.708 \text{ mm}$$

$$a) p_c = \pi d / N = \pi m$$

$$p_c = \pi (2.5)$$

$$p_c = 7.854 \text{ mm}$$

$$p_c p = \pi \rightarrow p = \pi / p_c$$

$$p = \pi / 7.854 \text{ mm}$$

$$p = 2/5 \text{ teeth/mm} \rightarrow 0.4 \text{ teeth/mm}$$

$$p_n = \pi / p$$

$$p_n = \pi / 0.4$$

$$p_n = 7.854 \text{ mm}$$

$$p_n = p_t \cos \psi \rightarrow p_t = p_n / \cos \psi$$

$$p_t = 7.854 / \cos 30$$

$$p_t = 9.069 \text{ mm}$$

$$p_x = p_t / \tan \phi$$

$$p_x = 9.069 / \tan (20)$$

$$p_x = 15.708 \text{ mm}$$

$$b) p_n = p_t / \cos \psi \rightarrow p_t = p_n \cdot \cos \psi$$

$$p_t = (2/5) \cos 30$$

$$p_t = \sqrt{3}/5 \text{ teeth/mm} \rightarrow p_t = 0.346 \text{ teeth/mm}$$

$$\cos \psi = \tan \phi_n / \tan \phi_t \rightarrow \tan \phi_t = \tan \phi_n / \cos \psi$$

$$\phi_t = \tan^{-1} (\tan 20 / \cos 30)$$

$$\phi_t = 22.796^\circ$$

$$p_t = 0.346 \text{ teeth/mm}$$

$$\phi_t = 22.796^\circ$$

$$c) a = 1/p_n$$

$$a = 1/0.4$$

$$a = 2.5 \text{ mm}$$

$$b = 1.25/p_n$$

$$b = 1.25/0.4$$

$$b = 3.125$$

$$d_p = N_o / p \cos \psi$$

$$d_p = 19 / 0.4 \cos 30^\circ$$

$$d_p = 54.85 \text{ mm}$$

$$d_G = N_G / p \cos \psi$$

$$d_G = 57 / 0.4 \cos 30$$

$$d_G = 164.54 \text{ mm}$$

$$a = 2.5 \text{ mm}$$

$$b = 3.125$$

$$d_p = 54.85 \text{ mm}$$

$$d_G = 164.54 \text{ mm}$$

13.10

$$\begin{aligned} \text{a) } N_p &= \frac{2k}{3 \sin^2(\phi)} (1 + \sqrt{1 + 3 \sin^2 \phi}) \\ N_p &= \frac{2(1)}{3 \sin^2(20^\circ)} (1 + \sqrt{1 + 3 \sin^2(20^\circ)}) \\ N_p &= 12.32 \\ N_p &= 13 \text{ teeth} \end{aligned}$$

$$\begin{aligned} \text{b) } N_p &= \frac{2k}{(1+2m) \sin^2 \phi} (m + \sqrt{m^2 + (1+2m) \sin^2 \phi}) \\ N_p &= \frac{2(1)}{(1+2(2.5)) \sin^2(20^\circ)} (2.5 + \sqrt{2.5^2 + (1+2m) \sin^2 20^\circ}) \\ N_p &= 14.64 \\ N_p &= 15 \text{ teeth} \end{aligned}$$

$$\begin{aligned} N_G &= \frac{N_p^2 \sin^2 \phi - 4k^2}{4k} - 2N_p \sin \phi \\ N_G &= \frac{15^2 \sin^2(20^\circ) - 4(1)^2}{4(1)} - 2(15) \sin(20^\circ) \\ N_G &= 45.49 \\ N_G &= 45 \text{ teeth} \end{aligned}$$

$$\begin{aligned} \text{c) } N_p &= \frac{2k}{\sin^2 \phi} \\ N_p &= \frac{2(1)}{\sin^2(20^\circ)} \\ N_p &= 17.097 \\ N_p &= 18 \text{ teeth} \end{aligned}$$

13.15

a) $p_n = \pi m_n$

$p_n = \pi (3)$

$p_n = 9.425 \text{ mm}$

$p_t = p_n / \cos \psi$

$p_t = 9.425 / \cos(25)$

$p_t = 10.399 \text{ mm}$

$p_x = p_t / \tan \psi$

$p_x = 10.399 / \tan(25)$

$p_x = 22.3 \text{ mm}$

$p_n = 9.425 \text{ mm}$

$p_t = 10.399 \text{ mm}$

$p_x = 22.3 \text{ mm}$

b) $m_t = p_t / \pi$

$m_t = 10.399 / \pi$

$m_t = 3.31 \text{ mm}$

$m_t = 3.31 \text{ mm}$

$\phi = 21.88^\circ$

$\phi = \tan^{-1}(\tan \psi / \cos \psi)$

$\phi = \tan^{-1}(\tan 20 / \cos 25)$

$\phi = 21.88^\circ$

c) $d_p = m_t N_p$

$d_p = (3.31)(18)$

$d_p = 59.58 \text{ mm}$

$d_p = 59.58 \text{ mm}$

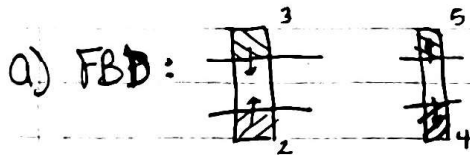
$d_G = 105.92 \text{ mm}$

$d_G = m_t N_G$

$d_G = (3.31)(32)$

$d_G = 105.92 \text{ mm}$

3.16



2 negative
3 positive
4 positive
5 negative

b) $n_c = n_5$
 $N_2/N_3 (N_4/N_5) n_c = n_c$
 $12/48 (16/36) 700 = n_c$

$n_c = 77.777 \text{ rev/min ccw}$

c) $d_{p2} = \frac{N_2}{P_{d2} \cos 4}$

$d_{p2} = \frac{12}{12 \cos(30)}$

$d_{p2} = 1.155 \text{ in}$

$d_{g3} = \frac{N_3}{P_{d3} \cos 4}$

$d_{g3} = 48/12 \cos 30$

$d_{g3} = 4.619 \text{ in}$

$C_{ab} = \frac{d_{p2} + d_{g3}}{2}$

$C_{ab} = \frac{1.155 + 4.619}{2}$

$C_{ab} = 2.887 \text{ in}$

$d_{p4} = \frac{N_4}{P_{d4} \cos 4}$

$d_{p4} = 16/8 \cos 25$

$d_{p4} = 2.207 \text{ in}$

$d_{p5} = \frac{N_5}{P_{d5} \cos 4}$

$d_{p5} = 36/8 \cos 25$

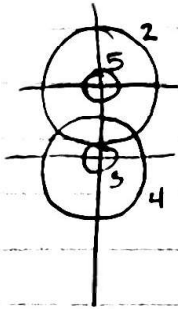
$d_{p5} = 4.9652 \text{ in}$

$C_{bc} = \frac{d_{p5} + d_{p4}}{2}$

$C_{bc} = 2.207 + 4.9652/2$

$C_{bc} = 3.5861 \text{ in}$

3.22



30	1
15	2
10	3
5	6

$$N_2/N_3 = 6 \quad N_4/N_5 = 5$$

$$N_2 + N_3 = N_4 + N_5$$

$$6 + 1 = 5N_5 + N_5$$

$$7 = 6N_5$$

$$7/6 = N_5$$

$$N_p = \frac{2k}{(1+2m) \sin^2 \phi} \left(m + \sqrt{m^2 + (1+2m) \sin^2 \phi} \right)$$

$$N_p = \frac{2(1)}{(1+2(6) \sin^2(20))} \left(6 + \sqrt{6^2 + (1+2(6) \sin^2(20))} \right)$$

$$N_p = 17.622$$

$$N_p = 18$$

$$\frac{N_2}{N_3} = 6$$

$$N_2 = 18 \cdot 6$$

$$N_2 = 108$$

$$N_2 + N_3 = N_4 + N_5$$

$$108 + 18 = 5N_5 + N_5$$

$$126 = 6N_5$$

$$N_5 = 21$$

$$N_4 = 105$$

$$N_2 = 108$$

$$N_3 = 18$$

$$N_4 = 105$$

$$N_5 = 21$$

13.24

$$N_2 + N_3 = N_4 + N_5$$

$$\omega_0/\omega_1 = 200/2500$$

$$\omega_0/\omega_1 = 1/8.333$$

$$\omega_0/\omega_1 = N_2/N_3 \cdot N_4/N_5$$

$$1/8.333 = (N_2/N_3)^2$$

$$1/2.887 = N_2/N_3$$

$$N_p = \frac{2k}{(1+2m) \sin^2 \phi} \left(m + \sqrt{m^2 + (1+2m) \sin^2 \phi} \right)$$

$$N_p = \frac{2(1)}{(1+2(2.887) \sin^2(20))} \left(2.887 + \sqrt{2.887^2 + (1+2(2.887) \sin^2(20))} \right)$$

$$N_p = 14.91$$

$$N_p = 15$$

$$N_2 = N_4 = 15$$

$$N_2/N_3 = 1/2.887$$

$$15/N_3 = 1/2.887$$

$$N_3 = 43.3$$

$$N_3 = 44 \text{ teeth}$$

$$N_3 = N_5 = 44 \text{ teeth}$$

$$\omega_0/\omega_1 = N_2/N_3 \cdot N_4/N_5$$

$$\omega_0/2500 = (15/44)(15/44)$$

$$\omega_0 = 290.5 \text{ rev/min}$$

$$N_2 = N_4 = 15 \text{ teeth}$$

$$N_3 = N_5 = 44 \text{ teeth}$$

$$13.33 \quad d_2 = T_2 \cdot m$$

$$d_2 = T_2 \cdot m$$

$$d_2 = 18 \cdot 12$$

$$d_2 = 216 \text{ mm}$$

$$d_3 = T_3 \cdot m$$

$$d_3 = 32 \cdot 12$$

$$d_3 = 384 \text{ mm}$$

$$d_4 = T_4 \cdot m$$

$$d_4 = 18 \cdot 12$$

$$d_4 = 216 \text{ mm}$$

$$d_5 = T_5 \cdot m$$

$$d_5 = 48 \cdot 12$$

$$d_5 = 576 \text{ mm}$$

$$W_{t2} = 60000 \frac{\text{H}}{\pi d_2 n}$$

$$W_{t2} = 60000 \frac{150}{\pi (216) 800}$$

$$W_{t2} = 7.36 \text{ KN}$$

$$W_{t3} = \frac{d_2}{2} = W_{t2} \frac{d_3}{2}$$

$$W_{t3} = \frac{216}{2} = \frac{384}{2}$$

$$W_{t3} = 13.08 \text{ KN}$$

$$W_{t3} = W_{t2} \tan \phi$$

$$W_{r3} = 13.08 \tan 20$$

$$W_{r3} = 4.76 \text{ KN}$$

Average

Grade:

Name: *Kelvin Boyd*

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Summary of Comments on Homework 1 (2).pdf

Page: 1

 Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:42:42 PM

If you were to put the problem statement, please make it bigger so it is legible.
Graded 13-15 and 13-24. 13-24 seems missing some steps. (-2)

8/10

13-3

13-3

A spur gearset has a module of 6 mm and a velocity ratio of 4. The pinion has 16 teeth. Find the number of teeth on the driven gear, the pitch diameters, and the theoretical center-to-center distance.

$$N_G = \text{Pinion} \cdot \text{Velocity Ratio}$$

$$N_G = 16(4) = 64 \text{ teeth}$$

$$d_G = N_G m = 64(6) = 384 \text{ mm}$$

$$d_P = N_P m = 16(6) = 96 \text{ mm}$$

$$C = \frac{384 + 96}{2} = 240 \text{ mm}$$

13-7

13-7

A parallel helical gearset consists of a 19-tooth pinion driving a 57-tooth gear. The pinion has a left-hand helix angle of 30° , a normal pressure angle of 20° , and a normal module of 2.5 mm. Find:

- (a) The normal, transverse, and axial/circular pitches
(b) The transverse diametral pitch and the transverse pressure angle
(c) The addendum, dedendum, and pitch diameter of each gear

$$N_P = 19 \text{ teeth} \quad \phi = 20^\circ$$

$$A) P_n = \pi m_n = \pi(2.5) = 7.85 \text{ mm}$$

$$N_G = 57 \text{ teeth} \quad m = 2.5 \text{ mm}$$

$$P_t = \frac{P_n}{\cos \psi} = \frac{7.85}{\cos 30^\circ} = 9.07 \text{ mm}$$

$$\psi = 30^\circ$$

$$P_x = \frac{P_t}{\tan \psi} = \frac{9.07}{\tan 30^\circ} = 15.71 \text{ mm}$$

$$B) m_t = \frac{m_n}{\cos \psi} = \frac{2.5}{\cos 30^\circ} = 2.89 \text{ mm}$$

$$\phi_t = \tan^{-1} \left(\frac{\tan \phi}{\cos \psi} \right) = \tan^{-1} \left(\frac{\tan 20^\circ}{\cos 30^\circ} \right) = 22.8^\circ$$

$$\begin{aligned}
 c) \quad a &= m_n = 2.5 \text{ mm} \\
 b &= 1.25 m_n = 3.125 \text{ mm} \\
 d_p &= \frac{N}{P_t} = N m_t = 84.85 \\
 d_G &= N_G m_t = 164.6 \text{ mm}
 \end{aligned}$$

13-10

13-10

For a spur gearset with $\phi = 20^\circ$, while avoiding interference, find:

- (a) The smallest pinion tooth count that will run with itself
- (b) The smallest pinion tooth count at a ratio $m_G = 2.5$, and the largest gear tooth count possible with this pinion
- (c) The smallest pinion that will run with a rack

$$\begin{aligned}
 A) \quad N_p &\geq \frac{2K}{3 \sin^2 \phi} (1 + \sqrt{1 + 3 \sin \phi}) \quad \text{Eq. 13-10} \\
 &\geq \frac{2(1)}{3 \sin^2 20^\circ} (1 + \sqrt{1 + 3 \sin 20^\circ}) \\
 &\geq 12.3 \text{ teeth round up to } 13
 \end{aligned}$$

K is always 1

$$\begin{aligned}
 B) \quad N_p &\geq \frac{2K}{(1 + 2m) \sin^2 \phi} (m + \sqrt{m^2 + (1 + 2m) \sin^2 \phi}) \quad \text{Eq. 13-11} \\
 &\geq \frac{2(1)}{(1 + 2(2.5) \sin^2 20^\circ)} (2.5 + \sqrt{2.5^2 + (1 + 2(2.5) \sin^2 20^\circ)}) \\
 &\geq 14.6 \text{ teeth round up to } 15 \text{ teeth}
 \end{aligned}$$

Eq. 13-12

$$N_G \leq \frac{N_P^2 \sin^2 \phi - 4K^2}{4K - 2N_P \sin^2 \phi}$$

$$\leq \frac{15^2 \sin^2 20^\circ - 4(1)^2}{4(1) - 2(15) \sin^2 20^\circ} = 48.5 \text{ teeth round down to } 45$$

c)

Eq. 13-13

$$N_P \geq \frac{2K}{\sin^2 \phi} = \frac{2(1)}{\sin^2 20^\circ} = 17.1 \text{ teeth round up to } 18$$

13-15

13-15 A parallel-shaft gearset consists of an 18-tooth helical pinion driving a 32-tooth gear. The pinion has a left-hand helix angle of 25° , a normal pressure angle of 20° , and a normal module of 3 mm. Find:
 (a) The normal, transverse, and axial circular pitches
 (b) The transverse module and the transverse pressure angle
 (c) The pitch diameters of the two gears

$$m_n = 3 \text{ mm} \quad N_P = 18$$

$$\psi = 25^\circ \quad N_G = 32$$

A) Eq. 13-3 $P_n = \pi m_n = 3\pi \text{ mm}$

Eq. 13-16 $P_t = \frac{P_n}{\cos \psi} = \frac{3\pi}{\cos 25^\circ} = 10.1 \text{ mm}$

13-17 $P_x = \frac{P_t}{\tan \psi} = \frac{10.1}{\tan 25^\circ} = 22.3 \text{ mm}$

B)

$$m_t = \frac{P_t}{\pi} = \frac{10.1}{\pi} = 3.21 \text{ mm}$$

$$\phi_t = \tan^{-1} \left(\frac{\tan \phi_n}{\cos \psi} \right) = \tan^{-1} \left(\frac{\tan 20^\circ}{\cos 25^\circ} \right) = 21.88^\circ \quad \text{Eq. 13-19}$$

$$c) \quad d_p = m_t N_p = 59.58 \text{ mm}$$

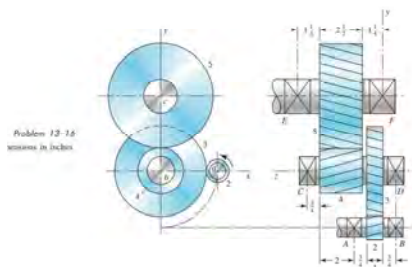
$$d_G = m_t N_G = 105.92 \text{ mm}$$

B-16

13-16

The double-reduction helical gearset shown in the figure is driven through shaft a at a speed of 700 rev/min. Gears 2 and 3 have a normal diametral pitch of 12 teeth/in, a 30° helix angle, and a normal pressure angle of 20° . The second pair of gears in the train, gears 4 and 5, have a normal diametral pitch of 8 teeth/in, a 25° helix angle, and a normal pressure angle of 20° . The tooth numbers are: $N_2 = 12$, $N_3 = 48$, $N_4 = 16$, $N_5 = 36$. Find:

- (a) The directions of the thrust force exerted by each gear upon its shaft
 (b) The speed and direction of shaft c
 (c) The center distance between shafts



A) Gear 2 - z direction
 Gear 3 + z direction
 Gear 4 + z direction
 Gear 5 - z direction

$$B) \quad N_c = n_s = \frac{N_2}{N_3} \left(\frac{N_4}{N_5} \right) (700)$$

$$= 77.78 \text{ rev/min ccw}$$

$$C) \quad d_{p2} = \frac{12}{12 \cos 30} = 1.16 \text{ in}$$

$$d_{G3} = \frac{48}{12 \cos 30} = 4.62 \text{ in}$$

$$C_{ab} = \frac{1.16 + 4.62}{2} = 2.89 \text{ in}$$

$$d_{p4} = \frac{16}{8 \cos 25} = 2.21 \text{ in}$$

$$d_{G5} = \frac{36}{8 \cos 25} = 4.97 \text{ in}$$

$$C_{bc} = 3.89 \text{ in}$$

13-22

13-20 A compound reverted gear train is to be designed as a speed increaser to provide a total increase of speed of exactly 45 to 1. With a 20° pressure angle, specify appropriate numbers of teeth to minimize the gearbox size while avoiding the interference problem in the teeth. Assume all gears will have the same diametral pitch.

13-21 Repeat Prob. 13-20 with a 25° pressure angle.
13-22 Repeat Prob. 13-20 for a gear ratio of exactly 30 to 1.

Eq. 13-30 $\phi = 20^\circ$ $K = 1$ $m = 6$

$$e = \frac{N_2}{N_3} \frac{N_4}{N_5} = 30 \quad \frac{N_2}{N_3} = 6 \quad \frac{N_4}{N_5} = 5$$

$$N_2 + N_3 + N_4 + N_5 \quad N_3 = 1 \quad N_2 + N_3 = N_4 + N_5$$

$$N_2 = 6$$

$$N_2 = 108 \text{ teeth}$$

$$N_3 = 18 \text{ teeth}$$

$$N_4 = 105 \text{ teeth}$$

$$N_5 = 21 \text{ teeth}$$

$$N_4 = 5N_5 \quad \gamma = 5N_5 + N_5$$

$$N_5 = \frac{7}{6}$$

13-24

13-24 A gearbox is to be designed with a compound reverted gear train that transmits 25 horsepower with an input speed of 2500 rev/min. The output should deliver the power at a rotational speed in the range of 280 to 300 rev/min. Spur gears with 20° pressure angle are to be used. Determine suitable numbers of teeth for each gear, to minimize the gearbox size while providing an output speed within the specified range. Be sure to avoid an interference problem in the teeth.

$H = 25 \text{ hp}$ $\omega_i = 2500 \text{ rev/min}$ $\omega_o = 300 \text{ rev/min}$

$$\frac{\omega_o}{\omega_i} = \frac{1}{8.33} = \frac{N_2}{N_3} \frac{N_4}{N_5} = \sqrt{\frac{1}{8.33}} = \frac{1}{2.887}$$

$$N_2 = N_4 = 15 \text{ teeth}$$

$$N_3 = N_5 = 43.31 \text{ teeth}$$

$$\omega_o = \left(\frac{15}{43} \right) \left(\frac{15}{43} \right) (2500) = 304.2 \text{ X}$$

$$\omega_o = \left(\frac{15}{4/4}\right) \left(\frac{15}{1/4}\right) (2500)$$

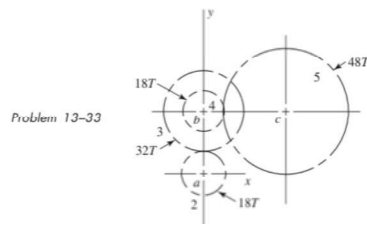
$$= 290.55 \text{ rev/min}$$

$$N_2 = N_1 = 15$$

$$N_3 = N_5 = 44$$

13-33

13-33 The gears shown in the figure have a module of 12 mm and a 20° pressure angle. The pinion rotates at 1800 rev/min (clockwise) and transmits 150 kW through the idler pair to gear 3 on shaft c. What forces do gears 3 and 4 transmit to the idler shaft?



$$m = 12 \text{ mm} \quad N_2 = 18$$

$$n_p = 1800 \text{ rev/min} \quad N_3 = 32$$

$$d_2 = 18(12) = 216 \text{ mm} \quad N_4 = 18$$

$$d_3 = 32(12) = 384 \text{ mm} \quad N_5 = 48$$

$$d_{41} = 18(12) = 216 \text{ mm}$$

$$d_5 = 48(12) = 576 \text{ mm}$$

Gear 2

13-36

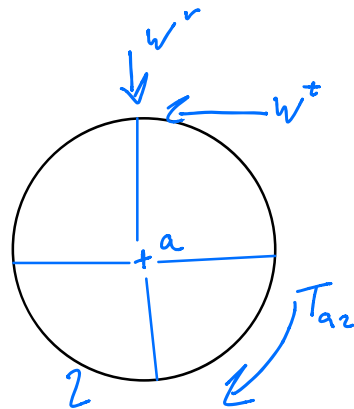
$$W_t = \frac{60,000 \text{ H}}{\pi d n} = \frac{60,000(150)}{\pi(216)(1800)}$$

$$= 7.368 \text{ kN}$$

$$T_{A2} = W_t \left(\frac{d_2}{2}\right)$$

$$= 7.368 \left(\frac{216}{2}\right) = 798.7 \text{ N}\cdot\text{m}$$

$$W^r = 7.368 \tan 20^\circ = 2.682 \text{ kN}$$

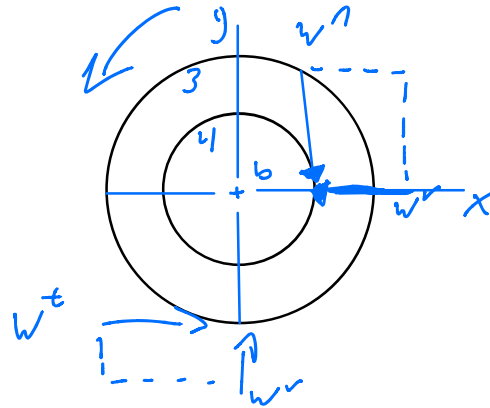


Gear 3+4

$$W^t \left(\frac{216}{2} \right) = 7.368 \left(\frac{381}{2} \right)$$

$$= 13.10 \text{ kN}$$

$$W^r = 13.10 \tan 20^\circ = 4.768$$



Below Average

13-15) $N_p = 19$, $N_g = 32$, $\psi = 25^\circ$, $\phi = 20^\circ$, $m_n = 3 \text{ mm}$

a)

$$P_n = \pi m_n = (3.14)(3 \text{ mm}) = 9.42 \text{ mm} = P_n$$

$$P_t = \frac{P_n}{\cos \psi} = \frac{9.42}{\cos(25)} = 10.4 \text{ mm} = P_t$$

$$P_x = \frac{P_t}{\tan \psi} = \frac{10.4 \text{ mm}}{\tan(25)} = 22.3 \text{ mm} = P_x$$

b) $m_t = \frac{P_t}{\pi} = \frac{10.4 \text{ mm}}{3.14} = 3.31 \text{ mm} = m_t$

$$\cos \psi = \frac{\tan \phi_n}{\tan \phi_t} \Rightarrow \phi_t = \arctan \left(\frac{\tan \phi_n}{\cos \psi} \right)$$

$$= \arctan \left(\frac{\tan(20)}{\cos(25)} \right) = \phi_t = 21.9^\circ$$

c) $d_p = m_t N_p = (3.31 \text{ mm})(19) = 62.9 \text{ mm} = d_p$

$d_g = m_t N_g = (3.31 \text{ mm})(32) = 105.9 \text{ mm} = d_g$

13-16) a) $\begin{matrix} \uparrow \text{ Gear 5} \\ \downarrow \text{ Gear 4} \end{matrix} \quad \begin{matrix} \downarrow \text{ Gear 3} \\ \uparrow \text{ Gear 2} \end{matrix} \quad \begin{matrix} N_2 = 12, N_3 = 48, N_4 = 16 \\ N_5 = 36 \end{matrix}$

b) speed of shaft c = speed of gear 5

speed of shaft a = speed of gear 2

$$n_5 = \left(\frac{N_2}{N_3} \right) \left(\frac{N_4}{N_5} \right) n_2 = \left(\frac{12}{48} \right) \left(\frac{16}{36} \right) (700 \frac{\text{rev}}{\text{min}}) = 77.8 \frac{\text{rev}}{\text{min}} = n_c$$

Summary of Comments on new doc 2020-09-16 09.17.04

Page: 1



Number: 1 Author: japark Subject: Sticky Note Date: 12/15/2020 12:43:21 PM

Missing cover sheet (-1) Graded 13-15 and 13-24. You have these two problems completed but is missing other five problems. (-3) Please let me know if you require any assistance.

6/10

13-24) Horsepower = 25 hp $\omega_i = 2500 \frac{\text{rev}}{\text{min}}$, $\omega_o = 300 \frac{\text{rev}}{\text{min}}$

$$n_c = \frac{N_2}{N_3} \frac{N_4}{N_5} \Rightarrow \frac{300}{2500} = \frac{N_2}{N_3} \frac{N_4}{N_5}$$

$$\sqrt{\frac{300}{2500}} = \frac{N_2}{N_3} = \frac{N_4}{N_5} = \frac{1}{2.887} = \frac{1}{M}$$

$$N_2 = \frac{2}{1 + 2(2.887) \sin^2(20^\circ)} \left(2.887 + \sqrt{2.887^2 + (1 + 2(2.887) \sin^2(20^\circ))} \right)$$

$$= 15 = N_4$$

$$N_3 = 2.887(15) = 43.31 \Rightarrow$$

$$\omega_o = \left(\frac{1}{4} \right) \left(\frac{15}{44} \right) 2500 \frac{\text{rev}}{\text{min}} = 290.5 \frac{\text{rev}}{\text{min}} = \omega_o$$

13-23) $\phi = 70^\circ$ $M = 12 \text{ mm}$ $N_p = 1800 \frac{\text{rev}}{\text{min}}$ CW $1A = 150 \text{ kW}$

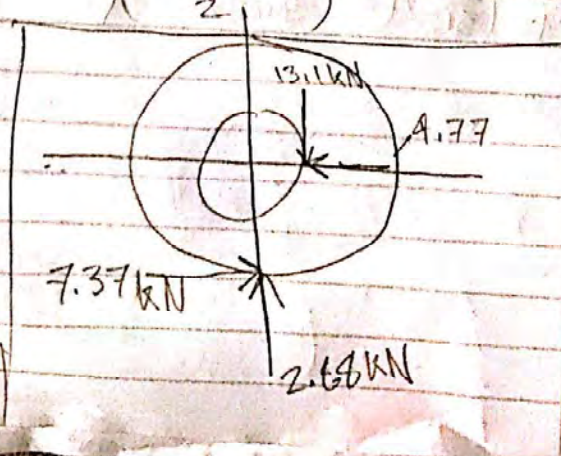
$$W = \frac{60,000 \text{ ft}}{\text{rev}} \cdot \frac{60,000(150 \text{ kW})}{\pi(12 \cdot 18)(1800 \frac{\text{rev}}{\text{min}})} = 7.368 \text{ kN} = W$$

$$W' = (7.368 \text{ kN})(\tan(10^\circ)) = 2.68 \text{ kN} = W'$$

$$W \left(\frac{12 \times 18}{2} \right) = 7.368 \left(\frac{12 \times 32}{2} \right)$$

$$W = 13.1 \text{ kN}$$

$$W' = 4.77 \text{ kN}$$



$$13-22) \quad e = \left(\frac{N_2}{N_3} \right) \left(\frac{N_4}{N_5} \right) = 30 \quad \frac{N_2}{N_3} = 6 \quad \frac{N_4}{N_5} = 5 \rightarrow N_4 = 5N_5$$

$$N_2 + N_3 = N_4 + N_5 = 6 + 1 = 7$$

$$7 = 5N_5 + N_3 \rightarrow N_3 = 7/6$$

$$N = 2 \quad \frac{1 + 2(6) \sin^2(20)}{6 + \sqrt{6^2 + 2(6) \sin^2(20)}} \rightarrow 16 \rightarrow 18 \text{ (d.n. sib by 6)} \quad \text{so } N_3 = 18$$

$$N_2 = 6(18) = 108 = N_2$$

$$108 + 18 = 126 = N_4 + N_5 \quad \frac{N_4}{N_5} = 5$$

$$N_4 = 105 \quad N_5 = 21$$

Grade:

Name:

J. Ball

This assignment is due at 10 AM on September 16th. Complete the following problems from Shigley's Mechanical Engineering Design – 10th edition.

1. Problem 13-3
2. Problem 13-7
3. Problem 13-10
4. Problem 13-15
5. Problem 13-16
6. Problem 13-22
7. Problem 13-24
8. Problem 13-33

Homework requirement

- Print this page and use it as the cover.
- The submission should be each student's own work.
- The same day late submission will get a 10% penalty.
- Once the solution is posted, no more submission will be accepted.
- Write legibly. No credit will be given if the work is not readable.
- Take advantage of office hours.
 - Tuesdays & Thursdays 1 PM ~ 3 PM (tentative, may change in the week of June 1st)
 - Email me: japark@pvamu.edu to request a Zoom meeting if you cannot make it to the regular office hour due to any university excused reasons.