May 4, 2022

INSTRUCTIONS

Begin each problem in the space provided. If additional space is required, use the paper provided to you.

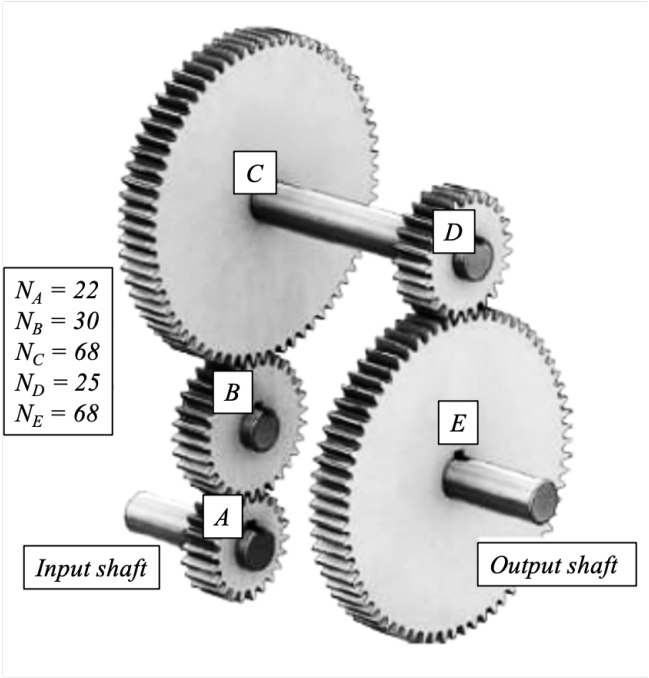
Work appearing on the backside of any exam page will NOT be graded.

If your solution does not follow a logical thought process, it will be assumed to be in error.

PROBLEM No. 1 (25 points)

Problem 1 consists of 10 questions. Each question is worth 2.5 points.

(a) The input of the compound gear train shown is gear A and the output is gear E.



Identify the idler(s) in the gear train.

☐ Gear A

☐ Gear B

☐ Gear C

☐ Gear D

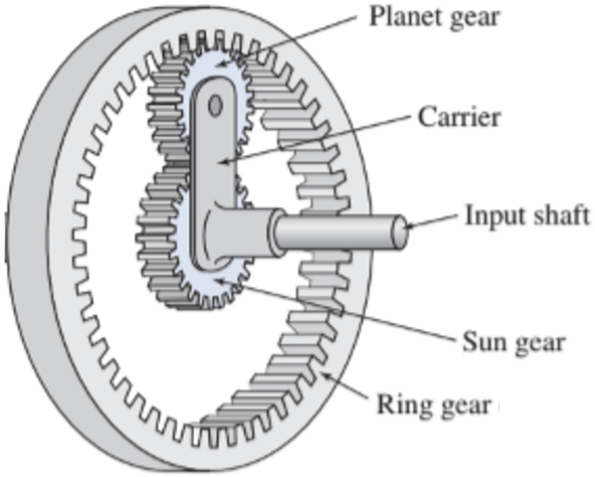
☐ Gear E

(b) Why are spur gears more efficient than helical gears?

(c) For the planetary gear-set shown, the input shaft is attached to the carrier and the diametral pitch is 12 teeth/inch.

The ring gear is fixed. The ring gear diameter is 6.5 inches.

The sun gear has 18 teeth.



Determine the number of teeth on the planet gear.

(d) For the planetary gear-set in part (c), determine the angular velocity of the planet gear if the carrier rotates at 900 rpm. Do the carrier and planet rotate in the same direction or in opposite directions?

(e) A steel bolt is used with a nut to clamp a 3 inch sandwich of aluminum. If the clamped material is changed from aluminum to copper, how will the joint stiffness constant be changed?

◯ C will decrease
◯ C will remain the same
◯ C will increase
◯ Cannot be determined with the given information

(f) What are the advantages of coarse-threaded fasteners over fine-threaded fasteners? Choose all that apply.

☐ Coarse-threaded fasteners are stronger in tension
☐ Coarse-threaded fasteners have better adjustment accuracy
☐ Coarse-threaded fasteners are more resistant to thread stripping
☐ Coarse-threaded fasteners have better fatigue life
☐ Coarse-threaded fasteners have faster assembly speed

(g) What is the torque needed to tighten a lubricated 1/2-20 SAE Grade 8 bolt to 80% of its proof strength?

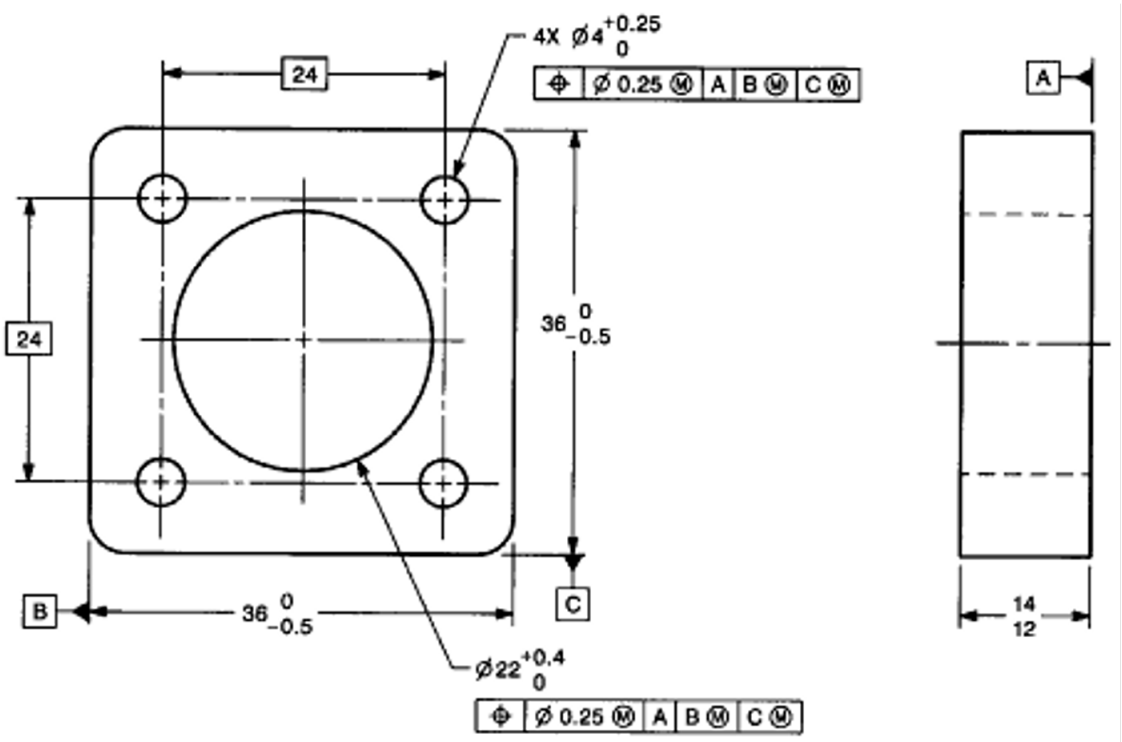
(h) An engineer designs a part with perfect geometry in CAD, but the produced part is never perfect.

Which approach allows for more manufacturing flexibility and larger tolerances by specifying the design intent of the part instead of the specific geometry?

◯ Traditional Dimensioning and Tolerancing (TD&T)

◯ Geometric Dimensioning and Tolerancing (GD&T)

(i) A GD&T drawing of a simple part is shown below. Circle five size attributes.



(j) What was the most interesting thing you learned in ME 354 this semester? Describe why in two or three sentences.

PROBLEM No. 2 (25 points)

An external spur gearset consists of a 18-tooth pinion and a 30-tooth gear. The pinion diameter is 1.5 inches and the gear diameter is 2.5 inches. Both gears have 20° full-depth teeth. The pinion rotates at 5100 rpm.

Determine the following.

(a) Complete the table on the next page with the variables needed to analyze the **pinion** for wear with the AGMA equation.

The life goal is 10^7 revolutions of the pinion.

The quality number is 6.

The gears are 4340 through-hardened grade 1 steels, heat-treated to 250 Brinell, core and case.

The load is moderate shock and the power is smooth.

The reliability is 95%.

(b) The face width of the pinion (F) to achieve $S_H = 1.6$.

(c) The power transmitted by the gearset in hp.

PROBLEM No. 2 (continued)

Include units in order to receive full credit.

Clearly describe how each variable was obtained (e.g., show the calculation, identify the equation, list the reference table/figure).

Variable	**Pinion**	**Supporting work, assumption and/or reference**
C_p		
W^t	100 lbf	Given
K_o		
K_v		
K_s		
K_m	1.7	Given
d_P		
C_f		
I		
S_c		
Z_N		
C_H		
K_T		
K_R		

PROBLEM No. 2 (continued)

PROBLEM No. 3 (25 points)

The compound gear train shown uses gear 2 as the input and gear 5 as the output.

The gear train is a speed reducer and needs to be designed for an exact train ratio of:

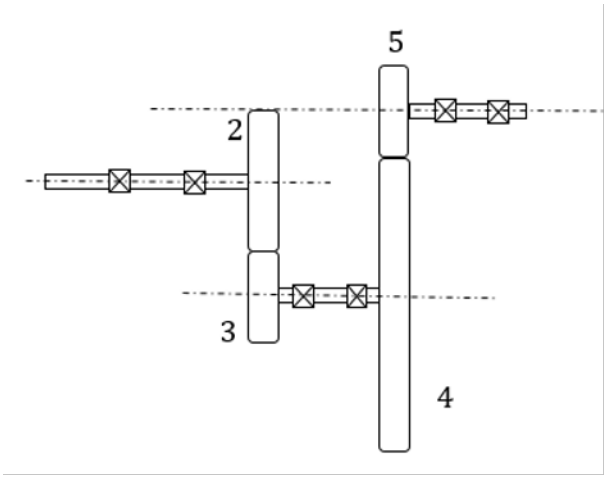
$$\frac{\omega_2}{\omega_5} = 35$$

Note that the figure is not drawn to scale but the gear diameters are constrained such that:

$$d_2 + \frac{d_3}{2} = \frac{d_4}{2} + \frac{d_5}{2}$$

Determine the minimum number of teeth on each gear for smallest overall size of the gear train, while avoiding interference for full-depth teeth with a pressure angle of 20°.

The module is constant for all gears in the gear train.



PROBLEM No. 3 (continued)

PROBLEM No. 4 (25 points)

A 0.5-in gray cast iron plate and a 1-in gray cast iron plate are joined with a 3/8-16 SAE Grade 5 steel screw. The 1-in plate is threaded through its entire thickness.

Determine the following.

(a) A suitable length for the screw.

(b) The bolt stiffness, k_b.

(c) The member stiffness, k_m.

(d) The joint stiffness constant, C.

(e) The preload in the bolt for a permanent connection, F_i.

(f) The factor of safety for infinite life using the Goodman criterion if the joint is loaded from $P_{min} = 1000$ lbf to $P_{max} = 2500$ lbf.

PROBLEM No. 4 (continued)