NAME, ID No:

18.1.2021, 15:00; Duration: 100 min

FALL 2020-2021
MKT 3821 Machine Elements FINAL EXAM

1. (25 pts)

Figure on the side shows a drive system in which a 20 kW electric motor drives three separate output shafts. Gear A is mounted on the motor shaft that has a rotational speed of 1750 rpm clockwise. Gear A drives a gear train consisting of gears B, C, and D that deliver power through the shafts on which they are mounted. All gears have a module of 6 mm.



Gear drive with multiple output shafts

The following data are given for the gear system:

Power delivered by gears B, C, and D:
PB = 8 kW, PC = 7 kW, PD = 5 kW

Numbers of teeth for all gears:

ID No's	***0, 3, 7***	***1, 4, 8***	***2, 5, 6, 9***
NA =	25	19	23
NB =	48	48	69
NC =	97	89	101
ND =	25	19	23

Determine the following of the drive system:
a. The pitch diameter of each gear.
b. The center distance of each gear mesh.
c. The rotational speed of each output shaft.
d. The torque through each output shaft.
e. The tangential force on the teeth of each gear.
f. Comment on the type of bearings that should be used on the B, C and D shafts. Explain the reason of your choice.

2. *(20 pts)* Select the rolling element bearings for a helical gear set, such that they are two identical Type-2 deep-groove ball bearings with minimum 90% reliability. **Use** the radial force and axial forces as given below. In your design, select an appropriate shaft diameter and your design life. You can use the tables given in books. Include the table scan in your solution.

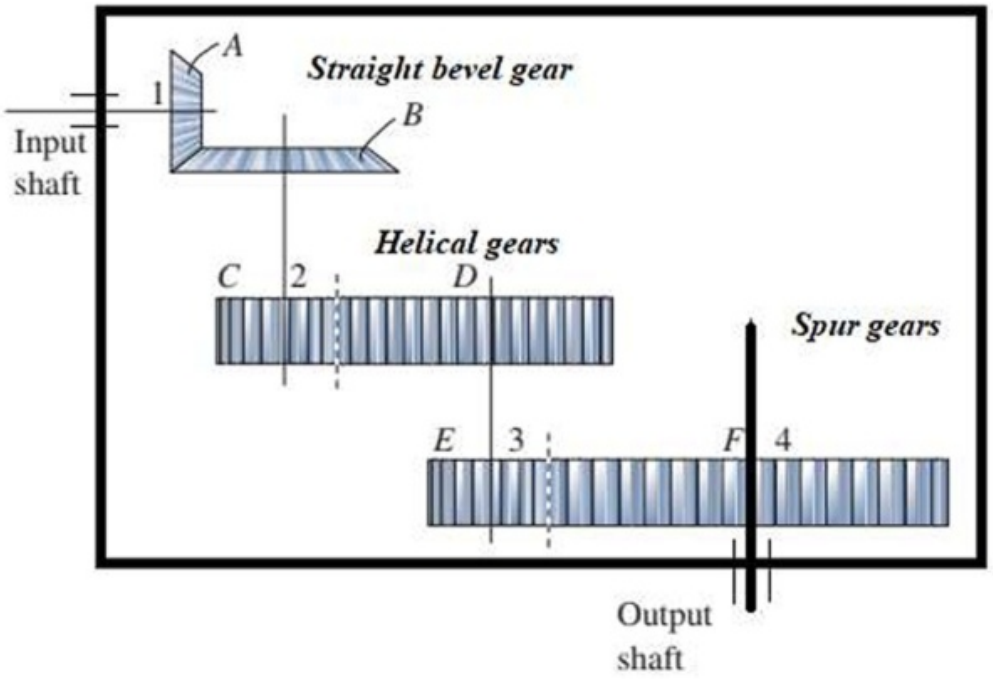
ID No's	***0, 4***	***1, 2***	***3, 6, 9***	***5, 7***
Radial F (N)	*3000*	*5000*	*6000*	*8000*
Axial F (N)	*600*	*1250*	*1600*	*3000*
Power source	*Electric motor*	*Diesel engine*	*Gasoline engine*	*Hydraulic motor*
Working condition	*Smooth, stable loads*	*Impact loading*	*Smooth, stable loads*	*Sinusoidally variable forces*

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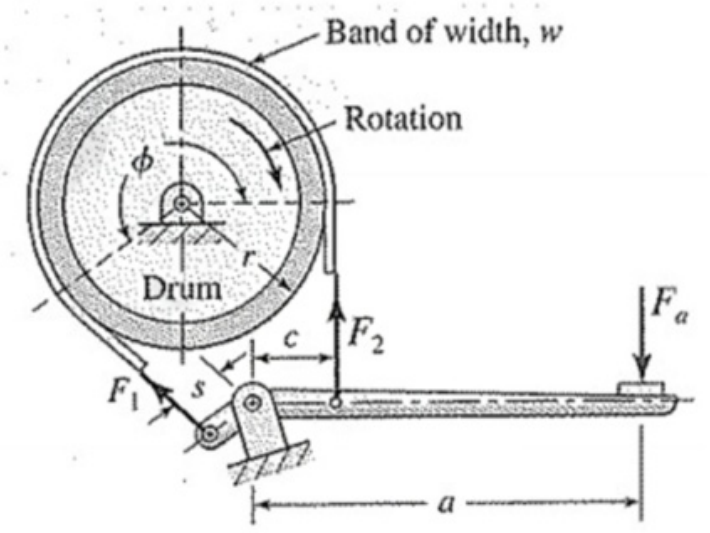
3. (20 pts)
Design the gearbox on the side kinematically.
Apply the gear and gear box design rules for optimum gear ratios and the required total reduction.
Inputs:
Power= 11 kW
Speed= 2900 rpm

Required outputs:
a) No of teeth on each gear.
b) Pressure, helix angles etc.
c) Approximate efficiency of the box.



ID No's	0, 2	1, 3, 5	4, 6	7, 9
R	100	120	150	130

4. (20 pts) A differential band brake similar to that in the figure below uses a woven lining having design values of f and pmax. The speed, a, c, r and s. w= 50 mm and ϕ=225 deg.
Predict the
(a) torque capacity
(b) actuating force
(c) power capacity
(d) the value s to cause the bracket to be self-locking.



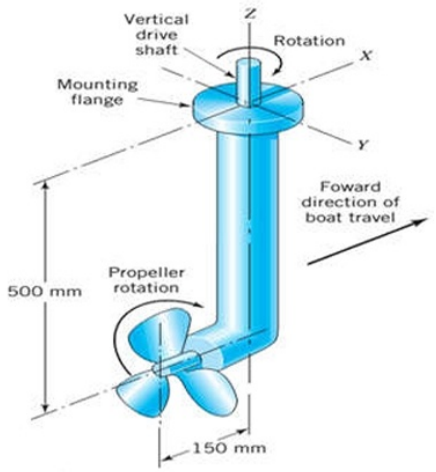
ID No's	ODD	EVEN
Friction coeff.	0,25	0,3
Pmax (kPa)	600	550
Speed (rpm)	400	500
a (mm)	400	350
c (mm)	50	45
r (mm)	300	250
s (mm)	40	35

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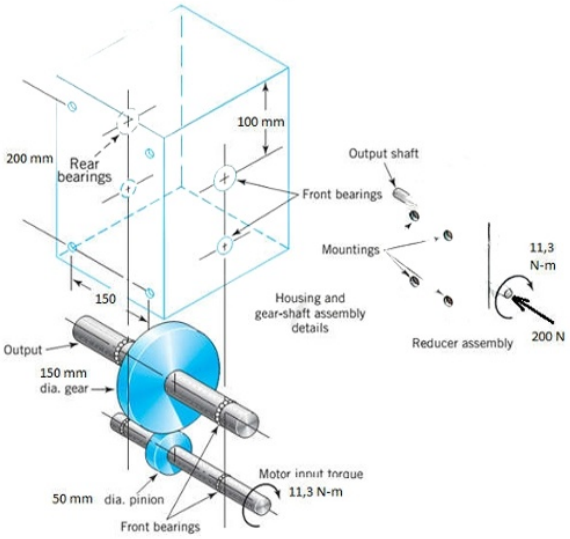
1. *(10 pts)* A journal bearing 40 mm in diameter and 50 mm long has a diametral clearance of 0,14 mm. The bearing rotates at 1400 RPM and it is lubricated using SAE 20 oil at an average temperature of 75°C. Using Petroff's equation, calculate the power loss and the friction torque.

2. *(15 pts) Find the force components in the* STRAIGHT *BEVEL GEAR set?*
The marine gearbox shown transmits 15 kW of power at 3300 rpm. Input is from the bevel pinion in the upper section and output is from the lower bevel gear in the lower section. The gear set and the shafts are made from a steel alloy with yield strength 660 MPa and ultimate tensile strength of 760 MPa.

The straight bevel gear set has 19 and 41 teeth of module 3 and pressure angle of 20 deg and width 15 mm.

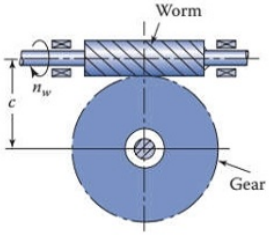


3. *(15 pts)* The helical gear set has 17 and 33 teeth of module 4, and pressure angle of 20 deg and helix angle 25 deg. The motor speed is 2800 rpm, input torque is 24,5 N-m and the axial force is 200 N.
Find the force components in the spur gear set?
Calculate the gear factor of safety on the basis of Lewis bending model assuming SAE 1045 water quenched and tempered steel (k_b=5).



4. *(10 pts)* Select the rolling element bearings for a helical gear set, such that they are two identical Type-2 deep-groove ball bearings with minimum 90% reliability. Use the table given. **Assume** the radial force as 3.000 N and axial force 600 N. In your design, select an appropriate shaft diameter and your design life?

5. *(10 pts)* The tension in a flat belt drive is 120 N when stationary. Calculate the tension on each side and the power transmitted at the point of slipping on the smaller wheel with 250 mm diameter and coefficient of firction of 0,3. Take the angle of lap as 150 degrees and ignore the centrifugal effects.



6. *(10 pts)* For the worm gearset shown,
(a) Find the **gear ratio**, **gear diameter** and **lead** of the worm
(b) **Helix angle** and **center distance** of the gears

Given: Nw=2 Ng=59 Module=4 (mm)
Assume: The worm gear diameter dw=5p. where p is the circular pitch of the gear.
(c) Check: Is the design rule satisfied?

7. *(10 pts)* A plate clutch consists of 1 pair of contacting surfaces. The inner and outer diameter of the friction disk is 120 mm and 200 mm, respectively. The coefficient of friction is 0.2 and permissible intensity of pressure is 1,5 N/mm². Assuming uniform wear theory, a) calculate the torque transmitting capacity of the clutch. b) calculate the operating force in the clutch.

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