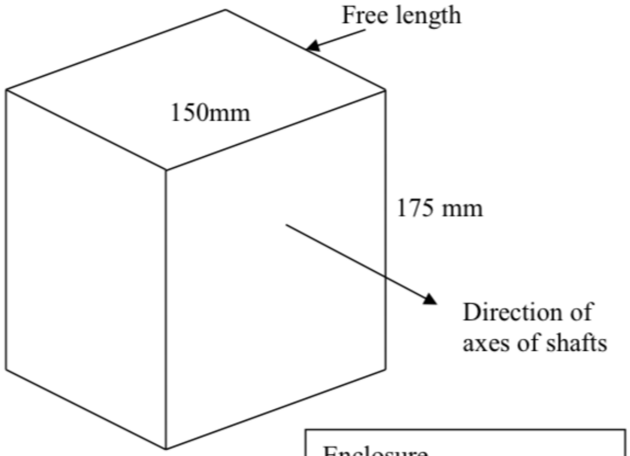
Objective: to familiarise the students with using the course gear catalogue to select gears that satisfy design requirements of strength, speed and space and avoid gear interference.

Task: You are to select a set of spur gears that operates under the following conditions.

Power transmitted = 1.2 kW
Input speed = 3100 rpm
Output speed = 130 ± 3% rpm
All round clearance = 3 mm
Enclosure is as shown. Shaft axes are to be aligned as shown.

a) Study the guidelines on selection of spur gears given in the course catalogue for NOZAG spur gears. The sizes of spur gears are also available in this catalogue. ✓

b) Select the gears for a quadruple (4 stage) gear reduction arrangement that will meet the speed, space and strength requirements. *Note: you can attempt a triple or double gear reduction arrangement which is more challenging and hence gain a better grade!*



Enclosure
Dimensions in millimetres

b) Select quadruple (4 stage) gear reduction arrangement

c) Show full detailed calculations in the selection of the gears, and also show determination of the 2 outermost gears in the compound gear train and hence the outermost dimensions in the compound gear train.

Speed Ratio (SR) = $\frac{\text{Input Speed}}{\text{Output Speed}}$,

$SR_T = \frac{3100}{130} = 23.85$

Train Speed Ratio : (Assume same SR for each stage)

$SR_T = SR_1 \times SR_2 \times SR_3 \times SR_4 = SR^4$

$SR = \sqrt[4]{23.85} = 2.209808223$

≈ 2.21

Stage 1

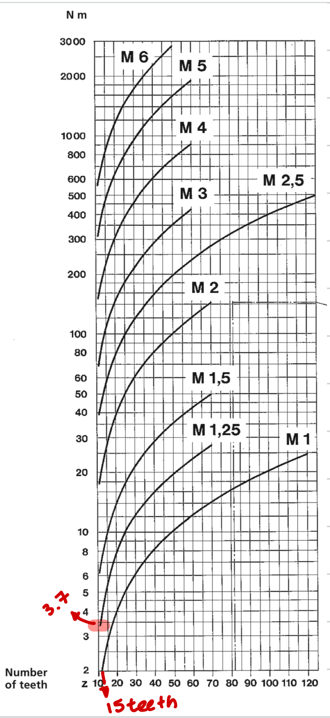
$T = \frac{P}{\omega}$, $T_1 = \frac{P_1}{\omega_1} = \frac{1.2 \times 10^3}{\frac{2\pi}{60} \times 3100} = 3.70\,Nm$

Table: combinations of number of teeth for spur gears in mesh to ensure no interference.

For a 20°, full-depth pinion meshing with a gear

Number of pinion teeth	Maximum number of gear teeth
18	Infinite
17	1 309
16	101
N_1 = 15	45 ✓
14	26
13	16

∴ No interference



From Table Z-056

→ $m_1 = 1.25$

→ $N_1 = 15$

→ $T_1 = 3.70\,Nm$

Finding N_2 & T_2 :

As $SR = \frac{N_2}{N_1}$, $N_2 = 2.20988223\,(15)$

$N_2 \approx 33.15$ teeth

N_2 : no of teeth selected for gear 2 = 35T

$\frac{T_G}{T_P} = \frac{N_G}{N_P} \Rightarrow \frac{T_2}{3.70} = \frac{35}{15}$

$T_2 = 8.633\,Nm$

Stage 2

$T_2 = T_3 = 8.633 Nm$

From Table Z-056
- $\rightarrow m_3 = 1.5$
- $\rightarrow N_3 = 15$
- $\rightarrow T_3 = 8.633 Nm$

Finding N_4 & T_4 :

As $SR = \frac{N_4}{N_3}$, $N_4 = 2.20988223 (15)$

$N_4 \approx 33.15$ teeth

N_4 : no of teeth selected for gear 4 = 35T

$\frac{T_G}{T_P} = \frac{N_G}{N_P} \Rightarrow \frac{T_4}{8.633} = \frac{35}{15}$

$T_4 = 20.14 Nm$

Stage 3

$T_4 = T_5 = 20.14 Nm$

From Table Z-056
- $\rightarrow m_5 = 2$
- $\rightarrow N_5 = 15$
- $\rightarrow T_5 = 20.14 Nm$

Finding N_6 & T_6 :

As $SR = \frac{N_6}{N_5}$, $N_6 = 2.20988223 (15)$

$N_6 \approx 33.15$ teeth

N_6 : no of teeth selected for gear 6 = 35T

$\frac{T_G}{T_P} = \frac{N_G}{N_P} \Rightarrow \frac{T_6}{20.14} = \frac{35}{15}$

$T_6 = 46.99 Nm$

Stage 4

$T_6 = T_7 = 46.99 Nm$

From Table Z-056
- $\rightarrow m_7 = 2.5$
- $\rightarrow N_7 = 15$
- $\rightarrow T_7 = 46.99 Nm$

Finding N_8 & T_8 :

$SR = \left(\frac{35}{15}\right)^3 \times \frac{N_8}{15}$, $N_8 = 28.16$

N_8 : no of teeth selected for gear 8 = 28 T

$\frac{T_G}{T_P} = \frac{N_G}{N_P} \Rightarrow \frac{T_8}{46.99} = \frac{28}{15}$

$T_8 = 87.71 Nm$

Checking

$\frac{n_{in}}{n_{out}} = \frac{N_2}{N_1} \times \frac{N_4}{N_3} \times \frac{N_6}{N_5} \times \frac{N_8}{N_7}$

$\frac{3100}{n_{out}} = \frac{35}{15} \times \frac{35}{15} \times \frac{35}{15} \times \frac{28}{15}$

$n_{out} = 130.73 rpm$

(within range ; $130 \pm 3\%$ rpm)

From their respective tables

Gear	N	m	d_a	d	Centre Distance
1	15	1.25	21.25	18.75	$\frac{43.75 + 18.75}{2} = 31.25$
2	35	1.25	46.25	43.75	
3	15	1.5	25.5	22.5	$\frac{52.5 + 22.5}{2} = 37.5$
4	35	1.5	55.5	52.5	
5	15	2.0	34	30	$\frac{70 + 30}{2} = 50$
6	35	2.0	74	70	
7	15	2.5	42.5	37.5	$\frac{70 + 37.5}{2} = 53.75$
8	28	2.5	75	70	

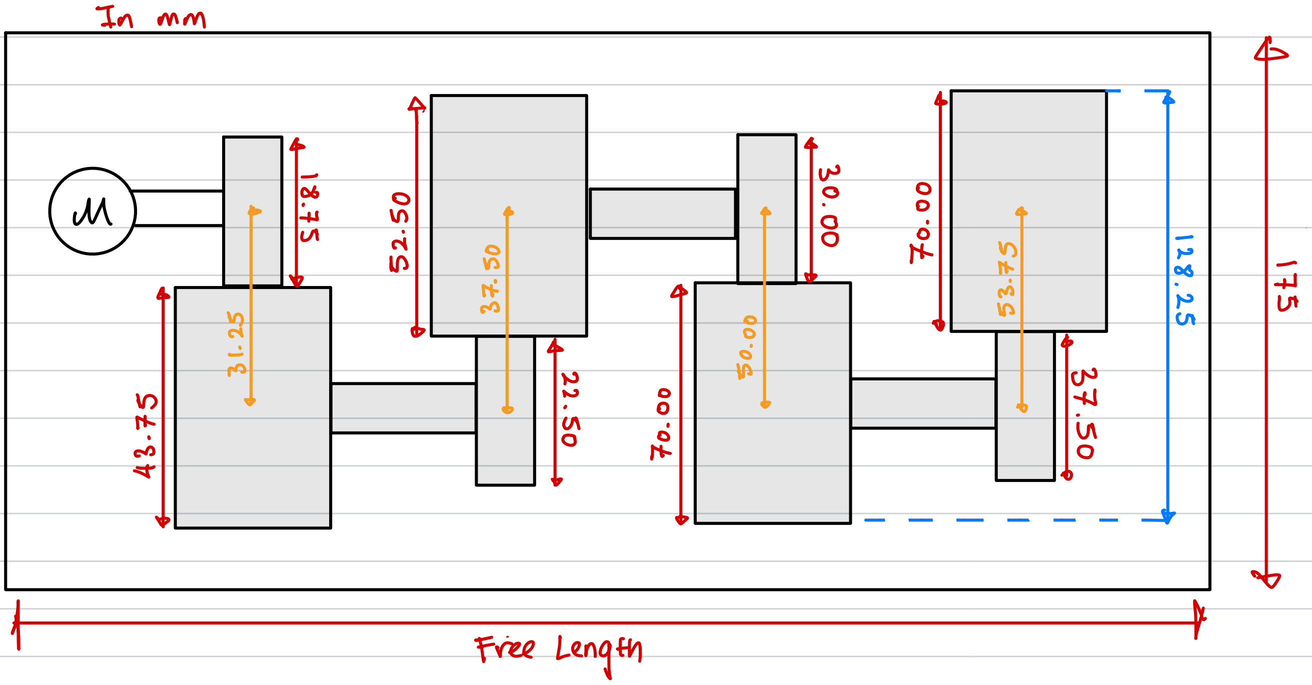
Check Dimensions :

$\frac{1}{2}(d_a)_6 + \frac{1}{2}(d_a)_8 + C_{7-8}$

$\frac{1}{2}(74) + \frac{1}{2}(75) + \frac{37.5 + 70}{2} = 128.25\,mm < 175\,mm$, Within Range

d) Make a dimensioned sketch of the compound gear layout (not necessary to scale).

In mm



3 Stage Gear Reduction

Speed Ratio (SR) $= \frac{\text{Input Speed}}{\text{Output Speed}}$,

$$SR_T = \frac{3100}{130} = 23.85$$

Train Speed Ratio : (Assume same SR for each stage)

$$SR_T = SR_1 \times SR_2 \times SR_3 = SR^3$$

$$SR = \sqrt[3]{23.85} = 2.8784$$

Stage 1

$$T = \frac{P}{\omega} \; , \; T_1 = \frac{P_1}{\omega_1} = \frac{1.2 \times 10^3}{\frac{2\pi}{60} \times 3100} = 3.70\,Nm$$

Finding N_2 & T_2 :

As $SR = \frac{N_2}{N_1}$, $N_2 = 2.8784(15)$

$N_2 \approx 43.176$ teeth

N_2 : no of teeth selected for gear 2 = 42 T

$$\frac{T_G}{T_p} = \frac{N_G}{N_p} \Rightarrow \frac{T_2}{3.70} = \frac{42}{15}$$

$$T_2 = 10.36\,Nm$$

Table: combinations of number of teeth for spur gears in mesh to ensure no interference.

For a 20°, full-depth pinion meshing with a gear	
Number of pinion teeth	Maximum number of gear teeth
18	Infinite
17	1 309
16	101
N_1=15	45 ✓
14	26
13	16

∴ No interference

Stage 2

$$T_2 = T_3 = 10.36\,Nm$$

From Table Z-056
- → $m_3 = 1.5$
- → $N_3 = 15$
- → $T_3 = 10.36\,Nm$

Finding N_4 & T_4 :

As $SR = \frac{N_4}{N_3}$, $N_4 = 2.8784(15)$

$N_4 \approx 43.176$ teeth

N_4 : no of teeth selected for gear 4 = 42T

$$\frac{T_G}{T_p} = \frac{N_G}{N_p} \Rightarrow \frac{T_4}{10.36} = \frac{42}{15}$$

$$T_4 = 29.01\,Nm$$

Stage 3

$$T_4 = T_5 = 29.01\,Nm$$

From Table Z-056
- → $m_5 = 2$
- → $N_5 = 15$
- → $T_5 = 29.01\,Nm$

Finding N_6 & T_6 :

As $SR = \frac{N_6}{N_5}$, $N_6 = 2.8784(15)$

$N_6 \approx 43.176$ teeth

N_6 : no of teeth selected for gear 6 = 42T

$$\frac{T_G}{T_p} = \frac{N_G}{N_p} \Rightarrow \frac{T_6}{29.01} = \frac{42}{15}$$

$$T_6 = 87.03\,Nm$$

If 45T,
$T_6 = 87.03\,Nm$ //

Checking

$$\frac{n_{in}}{n_{out}} = \frac{N_2}{N_1} \times \frac{N_4}{N_3} \times \frac{N_6}{N_5}$$

$$\frac{3100}{n_{out}} = \frac{42}{15} \times \frac{42}{15} \times \frac{42}{15}$$

$n_{out} = 141.217$ rpm ✗

(Not within range ; $130 \pm 3\%$ rpm)

If I select $N_2 = 42$ T, $N_3 = 15$ T, $N_4 = 42$ T, $N_5 = 15$ T, $N_6 = 45$ T

then

$$\frac{3100}{n_{out}} = \frac{42}{15} \times \frac{42}{15} \times \frac{45}{15}$$

$n_{out} = 131.80$ rpm ✓

(within range ; $130 \pm 3\%$ rpm)

From their respective tables

Gear	N	m		d_a	d	Centre Distance
1	15	1.25		21.25	18.75	$\frac{52.5 + 18.75}{2} = 35.625$
2	42	1.25		55	52.5	
3	15	1.5		25.5	22.5	$\frac{63 + 22.5}{2} = 42.5$
4	42	1.5		66	63	
5	15	2.0		34	30	$\frac{90 + 30}{2} = 60$
6	45	2.0		94	90	

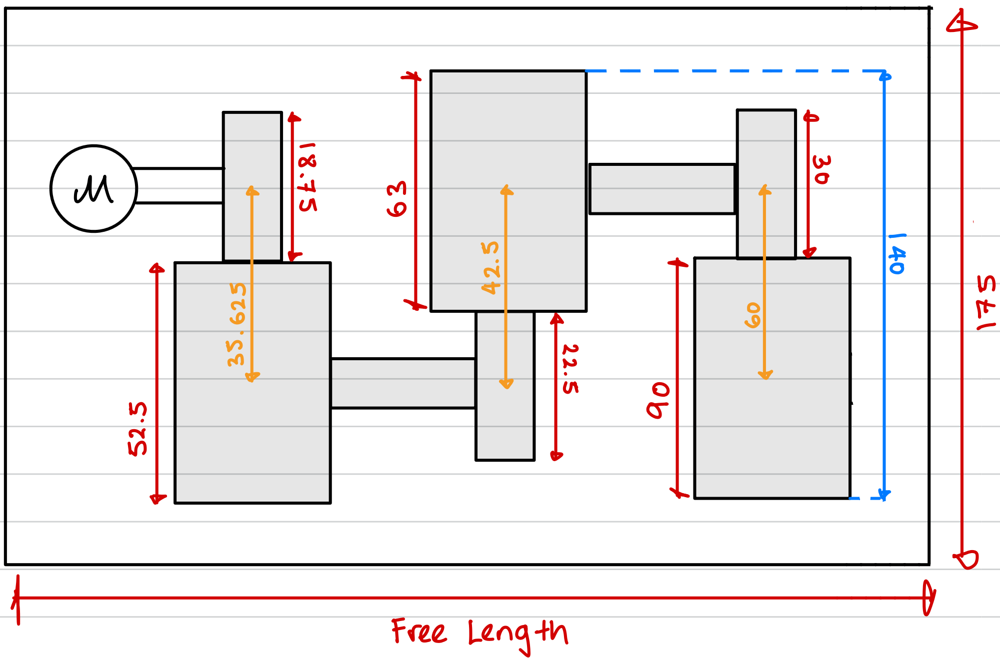
Check Dimensions :

$\frac{1}{2}(d_a)_4 + \frac{1}{2}(d_a)_6 + C_{5-6}$

$\frac{1}{2}(66) + \frac{1}{2}(94) + 60 = 140$ mm < 175 mm , Within Range

d) Make a dimensioned sketch of the compound gear layout (not necessary to scale).

In mm



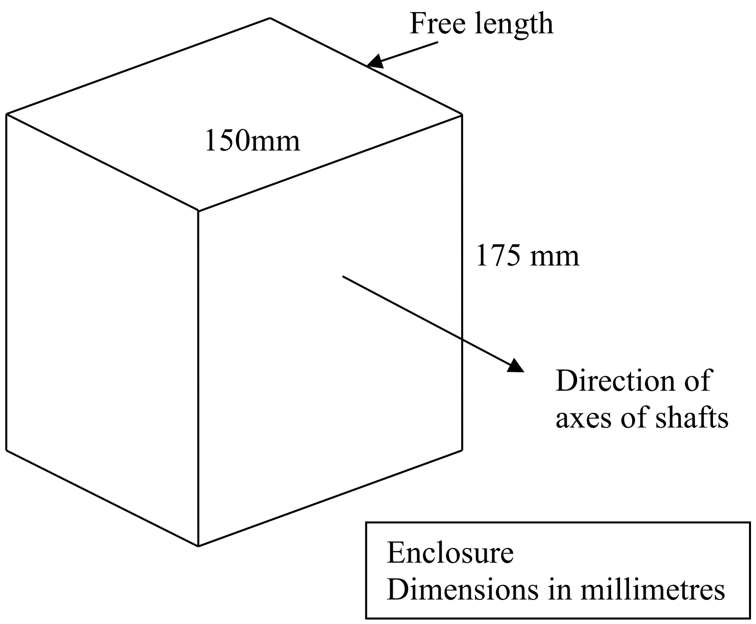
MA3001 CA4
Individual Assignment
Selection of Spur Gears

Objective: to familiarise the students with using the course gear catalogue to select gears that satisfy design requirements of strength, speed and space and avoid gear interference.

Task: You are to select a set of spur gears that operates under the following conditions.

Power transmitted = 1.2 kW
Input speed = 3100 rpm
Output speed = 130 ± 3% rpm
All round clearance = *to be assigned by Tutor*
Enclosure is as shown. Shaft axes are to be aligned as shown.

a) Study the guidelines on selection of spur gears given in the course catalogue for NOZAG spur gears. The sizes of spur gears are also available in this catalogue.
b) Select the gears for a quadruple (4 stage) gear reduction arrangement that will meet the speed, space and strength requirements. *Note: you can attempt a triple or double gear reduction arrangement which is more challenging and hence gain a better grade!*
c) Show full detailed calculations in the selection of the gears, and also show determination of the 2 outermost gears in the compound gear train and hence the outermost dimensions in the compound gear train.
d) Make a dimensioned sketch of the compound gear layout (not necessary to scale).



Requirements: Individual submission at the end of the session.

Suggested Steps:

1. Decide on gear ratio for each pair of meshing gears in the gear train.
2. Determine torque on each gear.
3. Decide on either number of teeth or module to select corresponding module or number of teeth
4. Check for no interference of meshing gears using the table below
5. Check for availability of gears from course catalogue
6. Check if final arrangement fits into the enclosed space (incl. addenda and all round clearance) by determining the 2 outermost gears in the compound gear train and hence the outermost dimensions in the compound gear train.

Table: combinations of number of teeth for spur gears in mesh to ensure no interference.

For a 20°, full-depth pinion meshing with a gear	
Number of pinion teeth	Maximum number of gear teeth
18	Infinite
17	1 309
16	101
15	45
14	26
13	16