

Mechanical Principles: Phase Test 2
Alexander Wright 1701086

Q1 $N = 1800 \text{ RPM}$
 $d_o = 120 \text{ mm } (0.12 \text{ m}) \quad r_o = 0.06 \text{ m}$
 $d_i = 40 \text{ mm } (0.04 \text{ m}) \quad r_i = 0.02 \text{ m}$
 $\mu = 0.45$
 $W = 900 \text{ N}$

Q1	10
Q2	4
Q3	7.5
Q4	5
Q5	10
	36.5
	50

i) $T = ?$

$$T = \frac{2}{3} \mu W \frac{(r_o^3 - r_i^3)}{(r_o^2 - r_i^2)} \times 2\pi$$

$$T = \frac{2}{3} \times 0.45 \times 900 \times \frac{(0.06^3 - 0.02^3)}{(0.06^2 - 0.02^2)}$$

$$T = 17.55 \text{ Nm}$$

$P = ?$

$$P = \frac{2\pi NT}{60}$$

$$P = \frac{2\pi \times 1800 \times 17.55}{60}$$

$$P = 3308.1 \text{ W } (3.31 \text{ kW})$$

73%

Q1

ii) $N = 1800 \text{ RPM}$

1.55 mm of wear

$$W = 6 \times 25 \text{ N/mm} \quad (150 \text{ N/mm})$$

~~$$T = \frac{\mu W (r_2 + r_1)}{2} \times 2a$$~~

~~$$T = \frac{0.45 \times 900 \times (0.06 + 0.02)}{2}$$~~

~~$$T = 16.2 \text{ Nm}$$~~

~~$P =$~~

$$W = 6 \times 1.55 \times 25 = 232.5 \quad \checkmark \text{ (reduction in axial force)}$$

$$900 - 232.5 = 667.5 \quad \checkmark$$

$$T = \frac{\mu W (r_2 + r_1)}{2} \quad \checkmark$$

$$T = \frac{0.45 \times 667.5 (0.06 + 0.02)}{2}$$

$$T = 12.02 \text{ Nm} \quad \checkmark$$

$$P = ?$$

$$P = \frac{2\pi \times 1800 \times 12.02}{60}$$

$$P = 2265.72 \text{ W} \quad (2.27 \text{ kW}) \quad \checkmark$$

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Q2

$$P = 5 \text{ kW (5000 W)}$$

$$N = 2500 \text{ RPM}$$

$$d = 130 \text{ mm (0.13 m)} \quad r = 0.065 \text{ m}$$

$$\mu = 0.4$$

$$\theta = 128^\circ$$

$$F_i = 250 \text{ N}$$

$$\theta = \frac{\pi}{180} \times 128 = 2.23 \text{ rad}$$

$$a) \quad V = \omega r = \frac{2\pi N}{60} \times \frac{d}{2} = \frac{2\pi \times 2500}{60} \times \frac{0.13}{2} \quad \checkmark$$

$$V = 17.02 \text{ m/s} \quad \checkmark$$

b) When Stationary

$$F_1 = F_i$$

$$F_1 + F_2 = \text{Constant}$$

$$F_2 = F_i$$

$$F_i + F_i = \text{Constant}$$

$$250 + 250 = \text{Constant}$$

$$500 \text{ N} = F_1 + F_2 \quad \checkmark$$

When under power

$$\frac{F_1}{F_2} = e^{\mu\theta} = e^{0.4 \times 2.23}$$

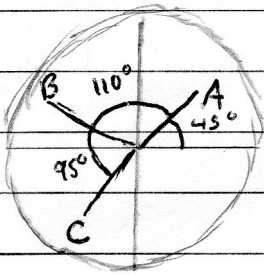
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$$\frac{F_1}{F_2} = 2.44 \quad \checkmark$$

... Shame you were going well.

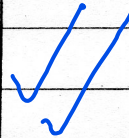
Q3

Q3

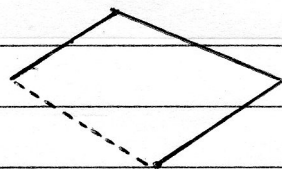


$$\begin{aligned}
 r_a &= 80 \text{ mm} \quad (0.08 \text{ m}) & m_a &= 0.87 \text{ kg} \\
 r_b &= 120 \text{ mm} \quad (0.12 \text{ m}) & m_b &= 0.55 \text{ kg} \\
 r_c &= 95 \text{ mm} \quad (0.095 \text{ m}) & m_c &= 0.58 \text{ kg} \\
 r_d &= 40 \text{ mm} \quad (0.04 \text{ m}) & m_d &= M_d
 \end{aligned}$$

	M (kg)	r (mm)	mr (kg-mm)
A	0.87	~~80~~ 80	69.6
B	0.55	120	66
C	0.58	95	55.1
D	m_d	40	$m_d 40$



Mr vector

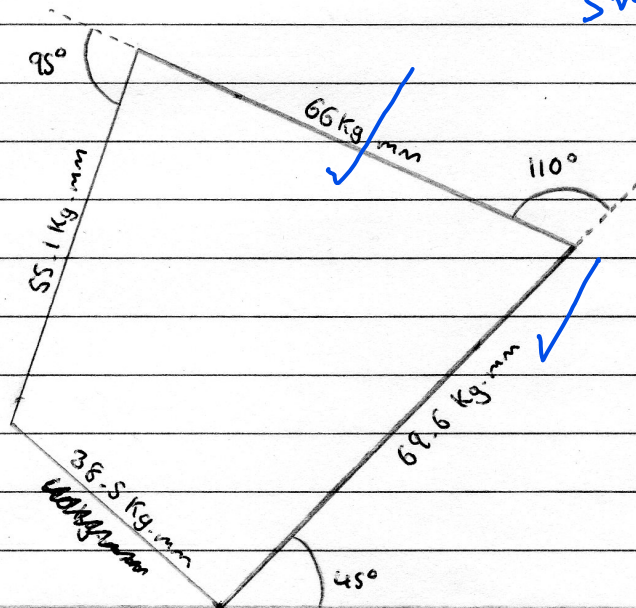


Sketch ✓

Q3

Scale = 1:1 (1 Kg.mm = 1 mm)

bit small



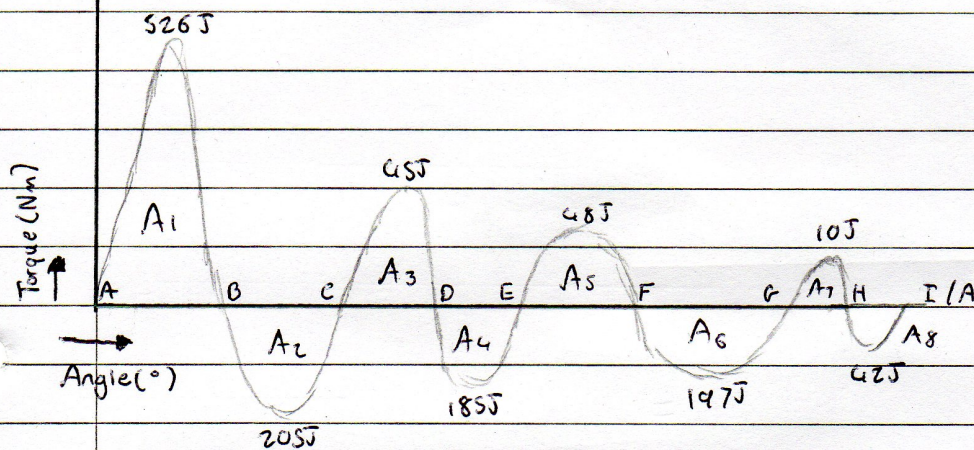
$$m_{drd} = 38.5 \text{ Kg.mm}$$

$$Q_{Omd} = 38.5 \text{ Kg.mm}$$

$$M_d = \frac{38.5}{40} = 0.975 \text{ Kg} \quad r = 40 \text{ mm} \quad @ 110^\circ$$

$$\frac{7.5}{10}$$

Q4 $N_1 = 2400 \text{ RPM}$
 $N_2 = 2500 \text{ RPM}$



a) $\phi = ?$
 ~~$\phi = ?$~~

$$\omega_1 = \frac{2\pi \times 2400}{60} \quad \omega_1 = 251.33 \text{ rad/s}$$

$$\omega_2 = \frac{2\pi \times 2500}{60} \quad \omega_2 = 261.8 \text{ rad/s}$$

$$\omega_m = \frac{\omega_1 + \omega_2}{2} \quad \omega_m = 256.565 \text{ rad/s} \quad (256.57)$$

$$\phi = \frac{\omega_2 - \omega_1}{\omega_m} = \frac{261.8 - 251.33}{256.565} = 0.033$$

b) $\beta W = ?$

Points	Energy (J)	Energy (J)
A	EA	EA (MIN)
B	EA + 526	EA + 526 (MAX)
C	EA + 526 - 205	EA + 321
D	EA + 526 - 205 + 45	EA + 366 ~~2000~~
E	EA + 526 - 205 + 45 - 185	EA + 181
F	EA + 526 - 205 + 45 - 185 + 48	EA + 229
G	EA + 526 - 205 + 45 - 185 + 48 - 197	EA + 32
H	EA + 526 - 205 + 45 - 185 + 48 - 197 + 10	EA + 42
I	EA + 526 - 205 + 45 - 185 + 48 - 197 + 10 - 92	EA

Good!
✓✓

$$\beta W = \text{MAX} - \text{MIN} = (EA + 526) - (EA)$$

$$\beta W = 526 \text{ J}$$

c) $I = ?$

$$I = \frac{\beta W}{\omega m^2 \phi}$$

$$I = \frac{526}{256.57 \times 0.003}$$

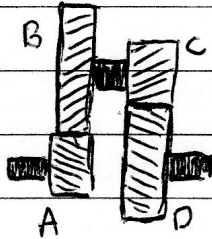
earned error

$$I = 0.24 \text{ kg} \cdot \text{m}^2$$

X

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Q5



$$t_a = 32 \quad t_b = 64 \quad t_c = 24 \quad t_d = 36$$

$$N_1 = 2500 \text{ RPM (anti clockwise)}$$

$$T_1 = 20 \text{ Nm}$$

$$\eta = 0.85$$

- a) Gears A & B, as well as ~~pair~~ C & D must each have the same module (pitch) to enable smooth ~~meshing~~ meshing of the teeth. ✓ Good!

b) Gear Ratio

$$\frac{B}{A} \times \frac{D}{C} = \frac{64}{32} \times \frac{36}{24} = 3 \quad \checkmark$$

$$GR = \frac{N_1}{N_2}$$

$$N_2 = \frac{N_1}{GR} \quad \checkmark$$

$$N_2 = \frac{2500}{3} = 833.33 \quad \checkmark$$

Output speed = 833.33 RPM (anti-clockwise)

c) $P = ?$

$$P_i = \frac{2\pi \times 2500 \times 20}{60} \quad \checkmark = 5235.99 \text{ W (5.24 kW)} \quad \checkmark$$

$$P_o = 5235.99 \times 0.85 = 4450.6 \text{ W (4.45 kW)} \quad \checkmark$$

$$d) \quad T_1 + T_2 + T_3 = 0$$

Output Torque :

$$P = \frac{2\pi NT}{60} \quad \frac{60P}{2\pi N} = T$$

$$T_0 = \frac{60 \times 4450.6}{2\pi \times 833.33} = 51 \text{ Nm}$$

$$20 + 51 + T_3 = 0$$

$$T_3 = 0 - (20 + 51) = -71 \text{ Nm holding torque}$$

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