



HND/C PHASE TEST SPECIFICATION

Programme:	HND Automotive Engineering / Motorsport Engineering				
Unit:	Mechanical Principles				
Phase Test No:	2	Lecturer:	T Tudor	Internal Verifier:	A Summerfield

Time and Date:	2012	Duration:	90 mins	Contribution to Overall Unit Assessment (%):	25%
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Outcomes being Assessed (from Unit Syllabus):

Number	Description
Learning Outcome 3:	Investigate power transmission system elements
Learning Outcome 4:	Investigate the dynamics of rotating systems

For Attention of Students:

Answer **ALL** questions.

The mark allocation is as indicated – total 40 marks.

A 'formula sheet' is provided for reference.

Assume 'g' = 9.81 m/s^2 .

and $1 \text{ bar} = 10^5 \text{ N/m}^2 (\text{Pa})$

1. Calculate:

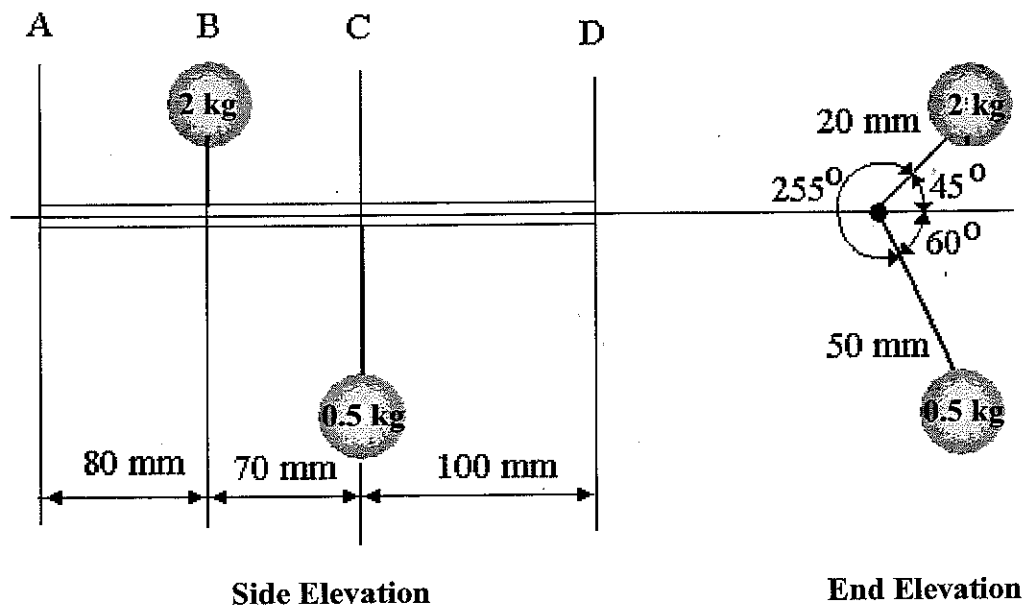
- i) The maximum torque and power which can be transmitted at 2000 RPM by a brand new clutch if it has an outer diameter of 120mm, an inner diameter of 40mm and a coefficient of friction of 0.45. The axial force may be taken as 800N.
- ii) The maximum torque and power which could be transmitted by the same clutch at 2000 RPM when worn by 1.3mm, if the axial force is provided by 4 springs, each with a rate of 15 N/mm.

(10 marks)

2. A belt drive must transmit 8 kW of power at 5000 rev/min. The pulley wheel is 120 mm diameter and the coefficient of friction is 0.3. The lap angle is 115° . If the initial belt tension must not exceed 180 N calculate the minimum number of belts required. Take the belt mass to be negligible.

(10 marks)

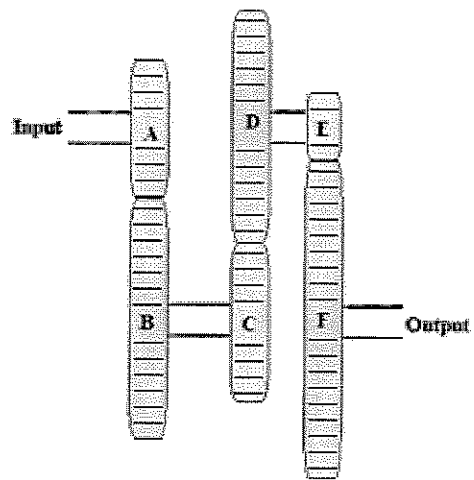
3. The diagram below shows masses on two rotors in planes B and C, 2kg at a radius of 20mm and 0.5kg at a radius of 50mm, respectively. Determine the masses and their positions, to be added on the rotors in planes A and D at radius 30 mm which will produce static and dynamic balance.



(10 marks)

4. The diagram below shows a compound gear train.

Gear A has 24 teeth
Gear B has 36 teeth
Gear C has 28 teeth
Gear D has 32 teeth
Gear E has 12 teeth
Gear F has 54 teeth



Gear A is the input gear and revolves at 1900 rev/min anticlockwise when viewed for the left end. If the input torque is 18 Nm and the gear train efficiency is 76% calculate the following;

- the output speed and direction
- the output power
- the holding torque required

(10 marks)

END OF TEST

21/ i) $N = 2000 \text{ RPM}$

$$d_o = 0.12 \text{ m} \Rightarrow r_o = 0.06 \text{ m}$$

$$d_i = 0.04 \text{ m} \Rightarrow r_i = 0.02 \text{ m} \checkmark$$

$$\mu = 0.45$$

$$W = 800 \text{ N}$$

$$T = \frac{2}{3} \mu W \frac{(r_o^3 - r_i^3)}{(r_o^2 - r_i^2)} = \frac{2}{3} \times 0.45 \times 800 \times \frac{(0.06^3 - 0.02^3)}{(0.06^2 - 0.02^2)} \checkmark$$

$$T = 15.6 \text{ Nm} \checkmark$$

$$P = \frac{2\pi N}{60} \times T = \frac{2\pi \times 2000}{60} \times 15.6 = 3267.26 \text{ W} \checkmark$$

ii)

$W_2 = W$ - spring force reduction

$$W_2 = 800 - (4 \times 1.3 \times 15) = 722 \checkmark$$

$$T = \frac{\mu W (r_o + r_i)}{2} \checkmark = \frac{0.45 \times 722 \times (0.06 + 0.02)}{2} \checkmark$$

$$T = 12.996 \text{ Nm} \checkmark$$

$$P = \frac{2\pi N}{60} \times T = \frac{2\pi \times 2000}{60} \times 12.996 = 2721.88 \text{ W} \checkmark$$

Q2/ $P = 8000 \text{ W}$
 $N = 5000 \text{ RPM} \rightarrow \omega = \frac{2\pi 5000}{60} = 523.599 \text{ rad s}^{-1}$
 $d = 0.12 \text{ m}$
 $\mu = 0.3$
 $\theta = 15^\circ = 2.007 \checkmark$
 $T_1 = 180 \text{ N}$

$$v = \omega r = 523.599 \times \frac{0.12}{2} = 31.42 \text{ m/s} \checkmark$$

When stationary

$$F_1 = F_2 = 180 \text{ N}$$

$$\text{Constant} = F_1 + F_2 = 360 \text{ N} \checkmark$$

$$\frac{F_1}{F_2} = e^{\mu \theta} = e^{0.3 \times 2.007} = 1.826 \checkmark$$

$$F_1 = 1.826 F_2$$

$$F_1 = 1.826 (360 - F_1)$$

$$F_1 = 232.61 \text{ N} \checkmark$$

$$F_2 = 127.39 \text{ N} \checkmark$$

$$\begin{aligned} \text{Power per belt} &= v(F_1 - F_2) = 31.42(232.61 - 127.39) \\ &= 3306 \text{ W} \checkmark \end{aligned}$$

$$N = \frac{8000}{3306} = 2.42 \therefore 3 \text{ belts}$$

P4
 $\eta = 0.76 \checkmark$

$$\begin{aligned} N &= 1900 \text{ RPM} \\ T_i &= 18 \text{ Nm} \end{aligned} \left. \vphantom{\begin{aligned} N &= 1900 \text{ RPM} \\ T_i &= 18 \text{ Nm} \end{aligned}} \right\} \text{anti clockwise}$$

$$\begin{aligned} t_A &= 24 \\ t_B &= 36 \\ t_C &= 28 \\ t_D &= 32 \\ t_E &= 12 \\ t_f &= 54 \end{aligned}$$

$$GR = \frac{t_b}{t_a} \times \frac{t_d}{t_c} \times \frac{t_f}{t_e}$$

$$GR = \frac{36}{24} \times \frac{32}{28} \times \frac{54}{12} \checkmark$$

$$GR = 7.74 \checkmark$$

$$N_2 = \frac{N_1}{GR} = \frac{1900}{7.74} = 246.296 \text{ RPM (clockwise)} \checkmark$$

$$P_i = \frac{2\pi N_1}{60} \times T_i = \frac{2\pi \times 1900}{60} \times 18 = 3581.42 \text{ W.}$$

$$P_o = \eta \times P_i = 3581.42 \times 0.76 = 2721.88 \text{ W}$$

$$T_o = \frac{60 P_o}{2\pi N_2} = \frac{60 \times 2721.88}{2\pi \times 246.296} = 105.531 \text{ Nm} \checkmark$$

(~~anti~~ clockwise)

$$T_1 + T_2 + T_h = 0 \checkmark$$

$$T_h = -T_1 - T_2 = -(-18) - (105.531)$$

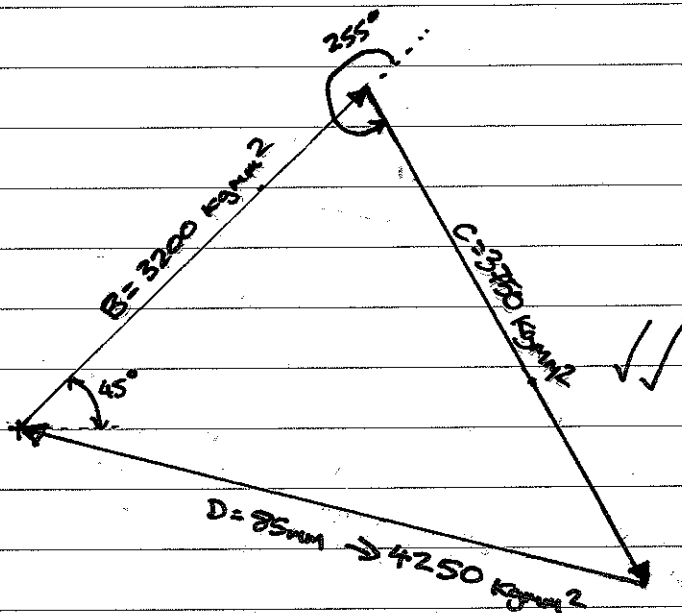
$$T_h = -87.53 \text{ Nm}$$

Q3/

	$M(\text{kg})$	$r(\text{mm})$	$Mr(\text{kgmm})$	$x(\text{mm})$	$Mrx(\text{kgmm}^2)$
A	m_a	30	$30m_a$	0	0
B	2	20	40	80	3200
C	0.5	50	25	150	3750 ✓✓
D	m_d	30	$30m_d$	250	$7500m_d$

Dynamically Balancing:

Mrx polygon: Scale $\Rightarrow 1\text{mm} = 50 \text{ kgmm}^2$



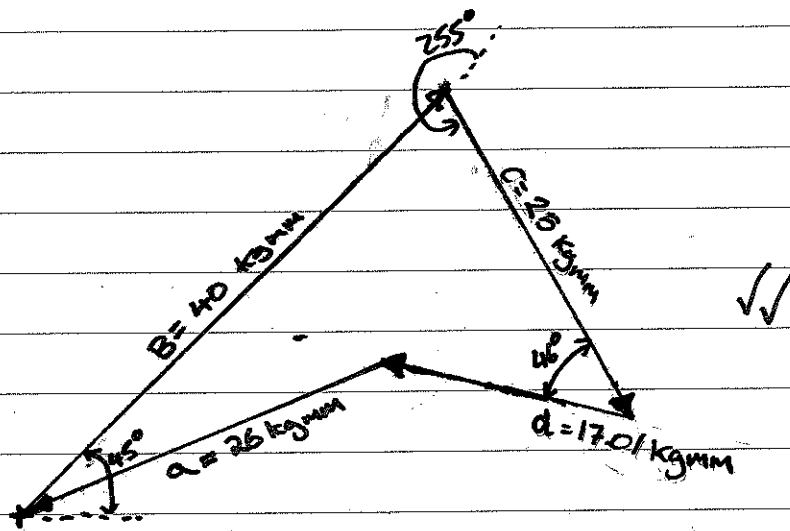
$$m_d r_d = 4250 = 7500 m_d$$

$$m_d = \frac{4250}{7500} = 0.567 \text{ kg. @ } 166^\circ \text{ from horizontal.}$$

Statically Balancing

Mr polygon: Scale $\Rightarrow 1\text{mm} = 0.5 \text{ kgmm}^2$

$$M_d r_d = 30 \times 0.567 = 17.01 \text{ kgmm.}$$



$$m_a a = 26 \text{ kgmm} = 30 m_a$$

$$m_a = \frac{26}{30} = 0.867 \text{ kg} \quad @ \quad 203^\circ \text{ from horizontal,}$$