



## 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% |
|----------------|------|-----------|---------|----------------------------------------------|-----|

| 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' =  $9.81 \text{ m/s}^2$ .

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

MODEL ANSWERS.

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)

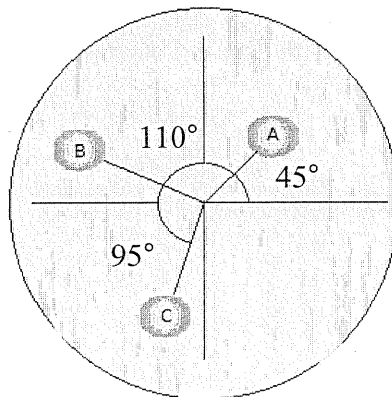
2. A belt drive must transmit 8 kW of power at 5000 rev/min. The pulley wheel is 120 mm diameter and the coefficient of friction is 0.3. The lap angle is  $115^\circ$ . If the initial belt tension must not exceed 180 N calculate the minimum number of belts required. Take the belt mass to be negligible.

(10 marks)

3. Three masses A, B and C are placed on a balanced disc as shown, at radii of 80 mm, 120 mm and 95 mm respectively.

The masses are 0.9 kg, 0.6 kg and 0.6 kg respectively.

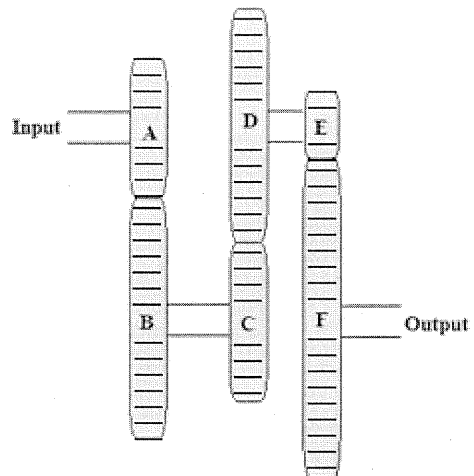
A fourth balancing mass is to be added to statically balance the system. Calculate the mass of this balancing mass, given it is to be placed at a radii of 50mm. Also determine the angular position at which it must be placed.



(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)  $N = 2000 \text{ RPM}$

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

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

$$\mu = 0.45$$

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

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

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

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

ii)

$W_2 = W$  - spring force reduction

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

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

$$T = 12.946 \text{ Nm}$$

$$P = \frac{2\pi N}{60} \times T = \frac{2\pi \times 2000}{60} \times 12.946 = 2721.88 \text{ W}$$

Q2/  $P = 8000 \text{ W}$   
 $N = 5000 \text{ RPM} \rightarrow \omega = \frac{2\pi 5000}{60} = 523.599 \text{ rads}^{-1}$   
 $d = 0.12 \text{ m}$   
 $\mu = 0.3$   
 $\theta = 115^\circ = 2.007 \text{ ✓}$   
 $T_i = 180 \text{ N}$

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

when stationary

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

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

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

$$F_1 = 1.826 F_2$$

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

$$F_1 = 232.61 \text{ N ✓}$$

$$F_2 = 127.39 \text{ N ✓}$$

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

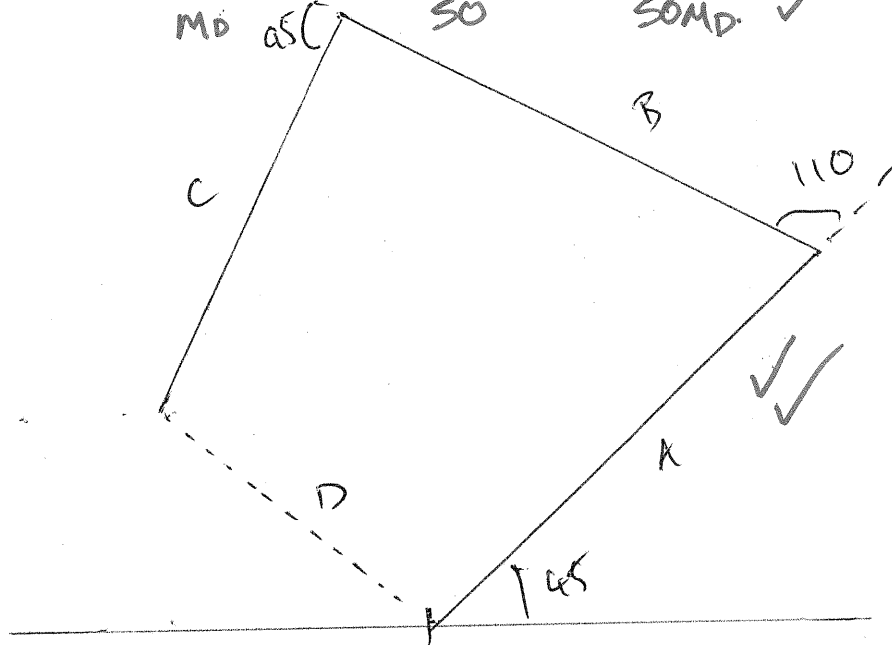
$$N = \frac{8000}{3306} = 2.42 \text{ ✓} \therefore 3 \text{ belts}$$

Q8

|   | Mass | r   | Mr     |
|---|------|-----|--------|
| A | 0.9  | 86  | 72 ✓   |
| B | 0.6  | 120 | 72 ✓   |
| C | 0.6  | 95  | 57 ✓   |
|   | MO   | 50  | SOMD ✓ |

Scale ✓

Approx



$h \approx 46 \text{ mm} \checkmark @ \approx 320^\circ \checkmark$

$Mr = 46 = m \times 50$

Approx.

$m = \frac{46}{50} = 0.92 \text{ kg} \checkmark$

54 /  $\eta = 0.76$

$$N = 1900 \text{ RPM} \quad \left. \begin{array}{l} T_i = 18 \text{ Nm} \end{array} \right\} \text{anti clockwise}$$

$$t_a = 24$$

$$t_b = 36$$

$$t_c = 28$$

$$t_d = 32$$

$$t_e = 12$$

$$t_f = 54$$

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

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

$$GR = 7.714 \checkmark$$

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

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

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

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

(~~anti~~ clockwise)

$$T_1 + T_2 + T_h = 0$$

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

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