



EXAMINATIONS 2012 / 2013

AHOLIADAU 2012 / 2013

Semester 2

FACULTY OF: Applied Design and Engineering

NAME OF COURSE/PROGRAMME: HND Motorsport/Automotive/Motorcycle Engineering

COHORT ENTRY POINT (Autumn or Spring): Autumn

YEAR OR LEVEL: Year 2

NAME OF MODULE/EXAM PAPER: Mechanical Principles : Phase Test 2 R1

MODULE NO:

DATE OF EXAMINATION: May 2013

EXAMINATION TIMES:

START TIME:	9.00 AM
FINISH TIME:	11.00 AM
TIME ALLOWED:	2 hours

INSTRUCTIONS TO CANDIDATES:

Answer **ALL** questions.

The mark allocation is as indicated – total **50 marks**.

A 'formula sheet' is provided for reference.

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

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

QUESTION ONE

Calculate:

- The maximum torque and power which can be transmitted at 3000 RPM by a brand new clutch if it has an outer diameter of 90mm, an inner diameter of 30mm and a coefficient of friction of 0.25. The axial force may be taken as 600N.
- The maximum torque and power which could be transmitted by the same clutch at 3000 RPM when worn by 2.3mm, if the axial force is provided by 6 springs, each with a rate of 20 N/mm.

(10 marks)

QUESTION TWO

A belt drive must transmit 5 kW of power at 2500 rev/min. The pulley wheel is 120 mm diameter and the coefficient of friction is 0.35. The lap angle is 120° . If the initial belt tension must not exceed 250 N calculate the minimum number of belts required. Take the belt mass to be negligible.

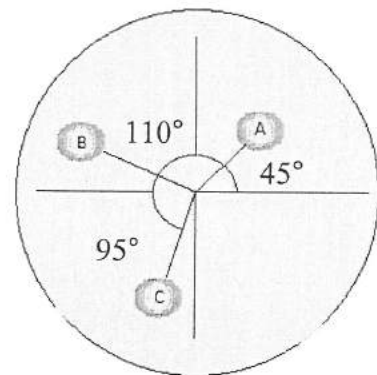
(10 marks)

QUESTION THREE

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.

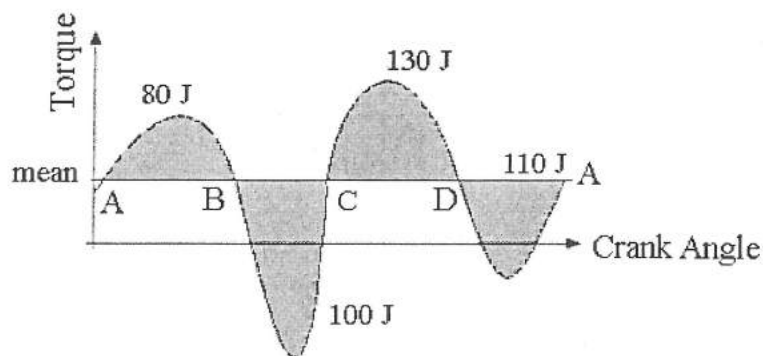
A fourth balancing mass is to be added to statically balance the system. Calculate the mass of this balancing mass, given it is to be placed at a radii of 50mm. Also determine the angular position at which it must be placed.



(10 marks)

QUESTION FOUR

The diagram shows a torque - angle diagram for a certain machine.



If the speed of the shaft must be maintained between 475 and 505 rev/min, calculate

- the moment of inertia of a suitable flywheel.
- the mass required if the flywheel has a radius of gyration is to be 0.25 m.

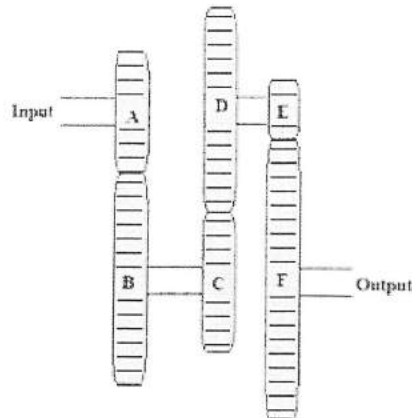
(10 marks)

QUESTION FIVE

The diagram below shows a compound gear train. Gear A is the input gear and revolves at 1000 rev/min anticlockwise when viewed for the left end. If the input torque is 30 Nm and the gear train efficiency is 75% calculate the following;

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

Gear A has 32 teeth
Gear B has 50 teeth
Gear C has 37 teeth
Gear D has 46 teeth
Gear E has 9 teeth
Gear F has 54 teeth



(10 marks)

Question 1

$$N = 3000 \text{ RPM}$$

$$d_o = 0.09 \text{ m}$$

$$d_i = 0.03 \text{ m}$$

$$\mu = 0.25$$

$$W = 600 \text{ N}$$

$$i) \quad r_2 = 0.045$$

$$r_1 = 0.015$$

$$T = \frac{2}{3} \mu W \frac{(r_2^3 - r_1^3)}{(r_2^2 - r_1^2)} = \frac{2}{3} \times 0.25 \times 600 \times \frac{(0.045^3 - 0.015^3)}{(0.045^2 - 0.015^2)}$$

$$T = 4.875 \text{ Nm}$$

$$P = \frac{2\pi N}{60} \times T = \frac{2\pi \times 3000}{60} \times 4.875 = 1.53 \text{ kW}$$

$$ii) \quad W_2 = W - \text{Spring force reduction}$$

$$W_2 = W - (n \times K \times u) = 600 - (6 \times 20 \times 13)$$

$$W_2 = 324 \text{ N}$$

$$T = \mu W \frac{(r_2 + r_1)}{2} = 0.25 \times 324 \times \frac{(0.045 + 0.015)}{2} = 2.43 \text{ Nm}$$

$$P = \frac{2\pi N}{60} \times T = \frac{2\pi \times 3000}{60} \times 2.43 = 0.763 \text{ kW}$$

Question 2

$$P = 5 \times 10^3 \text{ W}$$

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

$$d = 0.12 \text{ m}$$

$$\mu = 0.35$$

$$\theta = 120^\circ \longrightarrow 2.0944 \text{ rad}$$

$$T_2 = 250 \text{ N}$$

$$V = \omega r = \frac{2\pi \times 2500}{60} \times \frac{0.12}{2} = 15.71 \text{ m/s.}$$

When stationary $F_1 = F_2 = 250 \text{ N}$

$$\therefore \text{Constant} = \frac{500}{250} = F_1 + F_2$$

$$\frac{F_1}{F_2} = e^{\mu\theta} = e^{(0.35 \times 2.0944)} = 2.0814$$

$$F_1 = 2.0814 F_2$$

$$F_1 = 2.0814 (500 - F_1)$$

$$F_1 = \frac{1040.7}{3.0814} = 337.74 \text{ N}$$

$$F_2 = 162.26 \text{ N}$$

$$\begin{aligned} \text{Power per belt} &= v(F_1 - F_2) = 15.71 (337.74 - 162.26) \\ &= 2756.7 \text{ W} \end{aligned}$$

$$n = \frac{5000}{2756.7} = 1.81$$

$\therefore 2 \text{ belts.}$

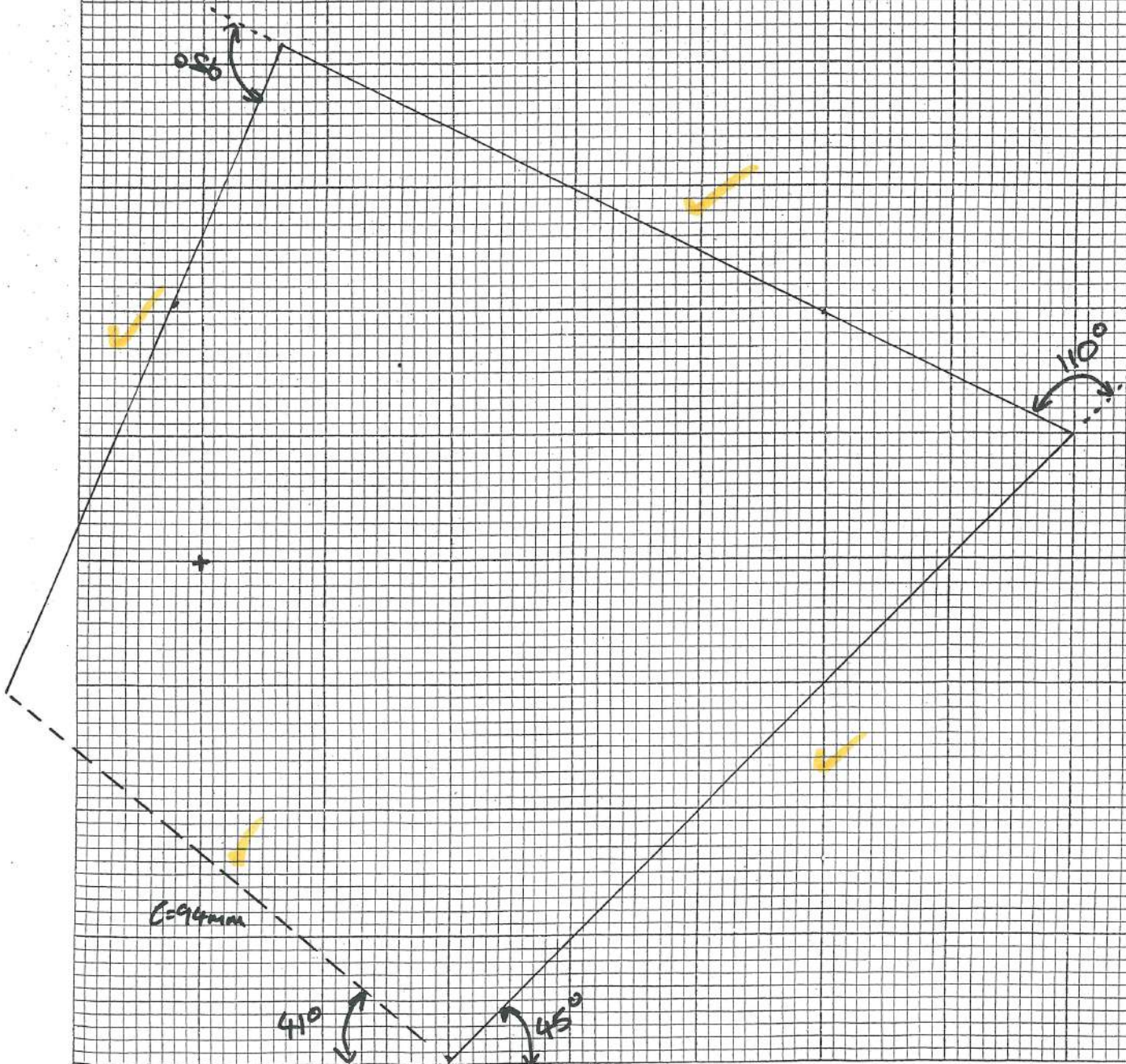
Question 3

	$m(\text{kg})$	$r(\text{mm})$	$mr(\text{kgmm})$	$C(\text{mm})$
A	0.9	80	72	144
B	0.6	120	72	144
C	0.6	95	57	114
D	m_D	50	$50m_D$	

Scale $1\text{mm} = 0.5\text{kgmm}$

$$50m_D = 47\text{ kgmm}$$

$$m_D = \frac{47}{50} = 0.94\text{ kg} @ 319^\circ \text{ to horizontal.}$$



Question 4

$$N_2 = 505 \text{ RPM}$$

$$N_1 = 475 \text{ RPM}$$

$$N_m = \frac{505 + 475}{2} = 490 \text{ RPM}$$

$$\omega_m = \frac{2\pi N_m}{60} = \frac{2\pi \times 490}{60} = 51.31 \text{ rad s}^{-1}$$

$$\phi = \frac{N_2 - N_1}{N_m} = \frac{505 - 475}{490} = 0.0612$$

Energy

A	E_A	$E_A +$
B	$E_A + 80$	$E_A + 80$
C	$E_A + 80 - 100$	$E_A - 20$
D	$E_A + 80 - 100 + 130$	$E_A + 110$
E	$E_A + 80 - 100 + 130 - 110$	E_A

$$\text{max} = E_A + 110 \quad \text{min} = E_A - 20$$

$$\text{Fluctuation} = \beta W = 130 \text{ J}$$

$$a) I = \frac{\beta W}{\omega_m^2 \phi} = \frac{130}{51.31^2 \times 0.0612} = 0.807 \text{ kg m}^2$$

$$b) I = m k^2$$

$$m = \frac{I}{k^2} = \frac{0.807}{0.25^2} = 12.91 \text{ kg}$$

Question 5

$$N_1 = 1000 \text{ RPM (anticlockwise)}$$

$$T_i = 30 \text{ Nm}$$

$$\eta = 0.75$$

$$t_a = 32$$

$$t_b = 50$$

$$t_c = 37$$

$$t_d = 46$$

$$t_e = 9$$

$$t_f = 54$$

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

$$GR = \frac{50}{32} \times \frac{46}{37} \times \frac{54}{9}$$

$$GR = 11.66$$

$$a) N_2 = \frac{N_1}{GR} = \frac{1000}{11.66} = 85.76 \text{ RPM (clockwise)}$$

$$b) P_i = \frac{2\pi N_1}{60} \times T_i = \frac{2\pi \times 1000}{60} \times 30 = 3.142 \text{ kW}$$

$$P_o = P_i \times \eta = 3.142 \times 10^3 \times 0.75 = 2.356 \text{ kW}$$

$$c) T_o = \frac{60 P_o}{2\pi N_o} = \frac{60 \times 2.356 \times 10^3}{2\pi \times 85.76} = 262.4 \text{ Nm (clockwise)}$$

$$T_i + T_o + T_h = 0$$

$$T_h = -T_i - T_o = -(-30) - (262.4) = -232.4 \text{ Nm (anticlockwise)}$$