



SWANSEA METROPOLITAN UNIVERSITY

PRIFYSGOL FETROPOLITAN ABERTAWE

EXAMINATION INTERNAL VERIFICATION FORM

MODULE :	Mechanical Principles	LEVEL:	5
PROGRAMME :	HND Motorsport / Automotive / Motorcycle Engineering	TERM OF EXAM: (SPRING OR SUMMER)	PhT2
LEARNING OUTCOME(S) BEING ASSESSED:	2. Analyse power transmission systems and undertake the dynamic balancing of rotating systems	EXAMINATION AUTHOR :	T.Tudor

VERSION:	DATE SUBMITTED FOR VERIFICATION:	INTERNAL VERIFIER COMMENTS (Approval or detail of amendments required):	DATE:
1.	27/09/13.	All good.	27/09/13.
2.			

INTERNAL VERIFIER PLEASE TICK TO INDICATE THAT THE EXAMINATION:	
	Conforms to the assessment pattern described in the module syllabus
	Tests the module learning outcome(s) appropriately

SIGNATURES OF FINAL APPROVAL:		SIGNATURE	DATE
INTERNAL VERIFIER: I confirm that this version of the exam paper is ready to be sent to the external examiner			27/09/13.
EXAM AUTHOR: I confirm that internal verifier and external examiner approval have been received and that this version of the exam paper is ready for printing.			



EXAMINATIONS 2013 / 2014 AHOLIADAU 2013 / 2014

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

MODULE NO:

DATE OF EXAMINATION: May 2014

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 5000 RPM by a brand new clutch if it has an outer diameter of 80mm, an inner diameter of 30mm and a coefficient of friction of 0.3. The axial force may be taken as 800N.
- The maximum torque and power which could be transmitted by the same clutch at 5000 RPM when worn by 1.0mm, if the axial force is provided by 8 springs, each with a rate of 25 N/mm.

(10 marks)

QUESTION TWO

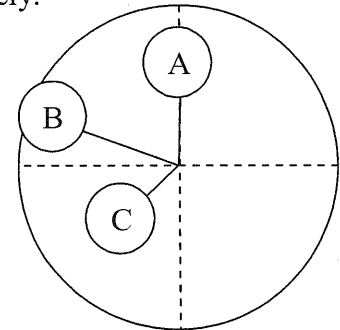
A belt drive must transmit 6 kW of power at 3000 rev/min. The pulley wheel is 100 mm diameter and the coefficient of friction is 0.28. The lap angle is 115° . If the initial belt tension must not exceed 150 N calculate the minimum number of belts required. Take the belt mass to be negligible.

(10 marks)

QUESTION THREE

Three masses A, B and C are placed on a balanced disc as shown, at radii of 75 mm, 100 mm and 60 mm at angular positions $+90^\circ$, $+160^\circ$ and $+205^\circ$ degrees respectively.

The masses are 0.2 kg, 0.25 kg and 0.4 kg respectively.

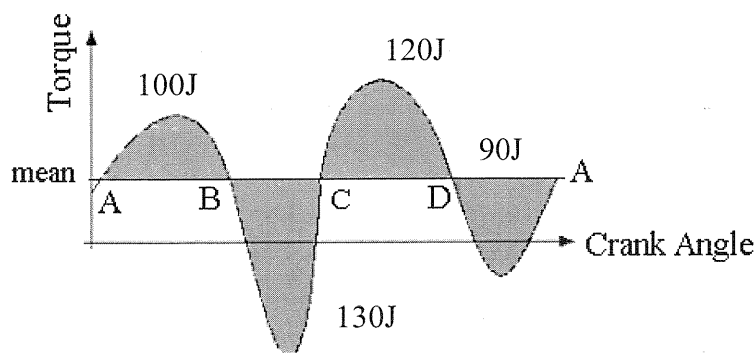


A fourth balancing mass is to be added to statically balance the system. Calculate the mass of this balancing mass, given it is to be placed at a radii of 80mm. Also determine the angular position at which is must be placed.

(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 850 and 950 rev/min, calculate

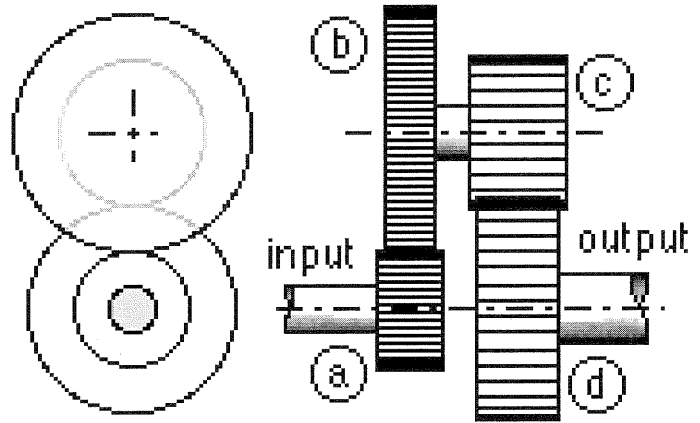
- the moment of inertia of a suitable flywheel.
- the mass required if the flywheel has a radius of gyration is to be 0.2 m. (10 marks)

QUESTION FIVE

The diagram below shows a compound gear train. Gear A is the input gear and revolves at 3000 rev/min anticlockwise when viewed for the left end. If the input torque is 20 Nm and the gear train efficiency is 88% calculate the following;

- a) the output speed and direction
- b) the output power
- c) the holding torque required

Gear A has 22 teeth
Gear B has 34 teeth
Gear C has 28 teeth
Gear D has 32 teeth



(10 marks)

Solutions

Q1

i) $n = 5000 \text{ RPM}$
 $d_o = 0.08 \text{ m}$
 $d_i = 0.03 \text{ m}$
 $\mu = 0.3$
 $W = 800 \text{ N}$

$r_o = 0.04 \text{ m}$ ✓
 $r_i = 0.015 \text{ m}$

$$T = \frac{2}{3} \mu W \frac{(r_o^3 - r_i^3)}{(r_o^2 - r_i^2)} = \frac{2}{3} \times 0.3 \times 800 \times \frac{(0.04^3 - 0.015^3)}{(0.04^2 - 0.015^2)} \checkmark$$

$$T = 7.05 \text{ Nm} \checkmark$$

$$P = \frac{2\pi N}{60} \times T = \frac{2\pi \times 5000}{60} \times 7.05 = 3.69 \text{ kW} \checkmark$$

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

$$W_2 = W - (n \times k \times u) \checkmark$$

$$W_2 = 800 - (8 \times 25 \times 1)$$

$$W_2 = 600 \text{ N} \checkmark$$

$$T = \frac{\mu W (r_o + r_i)}{2} = \frac{0.3 \times 600 \times (0.04 + 0.015)}{2}$$

$$T = 4.95 \text{ Nm} \checkmark$$

$$P = \frac{2\pi N}{60} \times T = \frac{2\pi \times 5000}{60} \times 4.95 = 2.59 \text{ kW} \checkmark$$

Q2

$$P = 6000 \text{ W}$$

$$N = 3000 \text{ rev/min}$$

$$d = 0.1 \text{ m}$$

$$\mu = 0.28$$

$$\theta = 115^\circ = 2.007 \text{ rad.} \checkmark$$

$$F_i = 150 \text{ N}$$

$$V = \omega r = \frac{2\pi N}{60} \times r = \frac{2\pi 3000}{60} \times 0.05 = 15.71 \text{ m/s}$$

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

$$\text{Constant} = F_1 + F_2 = 300 \text{ N} \checkmark$$

$$F_1/F_2 = e^{\mu\theta} = e^{0.28 \times 2.007} = 1.754 \checkmark$$

$$F_1 = 1.754 F_2$$

$$F_1 = 1.754(300 - F_1) \checkmark$$

$$F_1 = 526.2 - 1.754 F_1$$

$$2.754 F_1 = 526.2$$

$$F_1 = 191.07 \text{ N} \checkmark$$

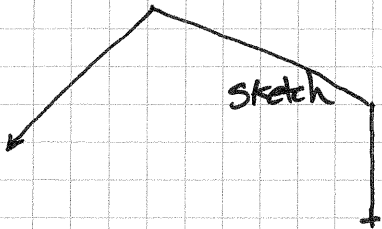
$$F_2 = 300 - 191.07 = 108.93 \text{ N} \checkmark$$

$$\begin{aligned} \text{Power per belt} &= r(F_1 - F_2) = 15.71(191.07 - 108.93) \\ &= 1290.4 \text{ W} \checkmark \end{aligned}$$

$$n = \frac{\text{Power}}{\text{power/belt}} = \frac{6000}{1290} = 4.65 \therefore 5 \text{ belts.} \checkmark$$

Q3

	$m(\text{kg})$	$r(\text{mm})$	$mr(\text{kgmm})$	$c(\text{mm})$
A	0.2	75	15	37.5
B	0.25	100	25	62.5
C	0.4	60	24	60
D	m_d	80	$80m_d$	117.5

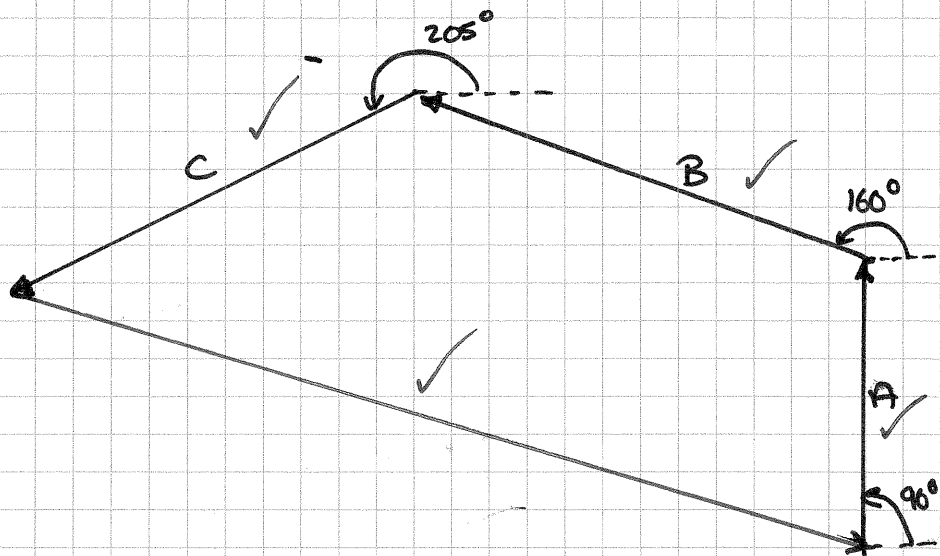


Sketch

Scale $1\text{kgmm} = 2.5\text{mm}$ ✓

$$80m_d = \frac{117.5}{2.5} = 47 \checkmark$$

$$m_d = \frac{47}{80} = 0.5875 \text{ Kg} \quad @ \quad 343^\circ \checkmark$$



Q4 $n_2 = 950 \text{ rev/min}$
 $n_1 = 850 \text{ rev/min}$

$$n_m = \frac{950 + 850}{2} = 900 \text{ rev/min} \checkmark$$

$$\omega_m = \frac{2\pi \cdot 900}{60} = 94.25 \text{ rad/s} \checkmark$$

$$\phi = \frac{n_2 - n_1}{n_m} = \frac{950 - 850}{900} = 0.111 \checkmark$$

Energy

A	E_A	E_A	
B	$E_A + 100$	$E_A + 100$	max
C	$E_A + 100 - 130$	$E_A - 30$	min ✓
D	$E_A + 100 - 130 + 120$	$E_A + 90$	
E	$E_A + 100 - 130 + 120 - 90$	E_A	

$$BW = \text{max} - \text{min} = (E_A + 100) - (E_A - 30) = 130 \text{ J} \checkmark$$

$$a) I = \frac{BW}{\omega_m^2 \phi} = \frac{130}{94.25^2 \times 0.111} = 0.133 \text{ kgm}^2 \checkmark$$

$$b) I = mk^2$$

$$m = \frac{I}{k^2} = \frac{0.133}{0.2^2} = 3.296 \text{ kg} \checkmark$$

Q5

$$N_i = 3000 \text{ rev/min} \quad \text{anticlockwise}$$

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

$$\eta = 0.88$$

$$t_a = 22$$

$$t_b = 34$$

$$t_c = 28$$

$$t_d = 32$$

$$GR_{ab} = t_b/t_a = 34/22 = 1.545 \checkmark$$

$$GR_{cd} = t_d/t_c = 32/28 = 1.143 \checkmark$$

$$GR = GR_{ab} \times GR_{cd} = 1.766 \checkmark$$

$$a) N_2 = \frac{N_1}{GR} = \frac{3000}{1.766} = 1698.5 \text{ rev/min} \quad \text{anticlockwise}$$

$$b) P_i = \frac{2\pi N_i}{60} \times T_i = \frac{2\pi \times 3000}{60} \times 20 = 6283.2 \text{ W}$$

$$P_o = \eta \times P_i = 0.88 \times 6283.2 = 5529.2 \text{ W}$$

$$c) T_o = \frac{60P}{2\pi N} = \frac{60 \times 5529.2}{2\pi \times 1698.5} = 31.09 \text{ Nm}$$

$$T_i + T_o + T_h = 0 \quad \text{anticlock +ve}$$

$$T_h = -T_i - T_o = -20 - 31.09 = -51.09 \text{ Nm}$$

$$\therefore T_h = 51.09 \text{ Nm} \quad \text{clockwise}$$