



EXAMINATION SOLUTIONS

(to accompany the examination paper sent to the external examiner
but NOT to be seen by students)

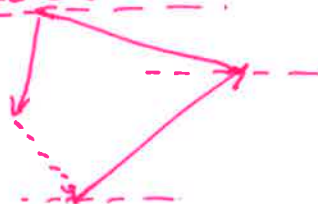
Programme:	BSc/HND Motorsport/Automotive Engineering	Level:	5.
Module:	Mechanical Principles.		
Author:	T.Tudor	Page:	

Q	Question	Marks
Q1	$N = 1800 \text{ RPM}$ $d_o = 0.12 \text{ m} \rightarrow r_2 = 0.06 \text{ m}$ $d_i = 0.04 \text{ m} \rightarrow r_1 = 0.02 \text{ m}$ $\mu = 0.45$ $\omega = 900$ <i>i)</i> $T = \frac{2}{3} \mu \omega \frac{(r_2^3 - r_1^3)}{(r_2^2 - r_1^2)}$ ✓ $T = \frac{2 \times 0.45 \times 900 \times (0.06^3 - 0.02^3)}{3(0.06^2 - 0.02^2)} = 17.55 \text{ Nm}$ ✓ $P = \frac{2\pi N}{60} \times T = \frac{2\pi 1800}{60} \times 17.55 = 3.31 \text{ kW.}$ ✓ <i>ii)</i> $\Delta W = \delta \times K \times n = 1.55 \times 25 \times 6$ ✓ $\Delta W = 232.5$ $\omega' = 900 - 232.5 = 667.5 \text{ N}$ ✓ $T = \frac{\mu \omega (r_2 + r_1)}{2} = \frac{0.45 \times 667.5 (0.06 + 0.02)}{2}$ ✓ $T = 12.015 \text{ Nm}$ ✓ $P = \frac{2\pi 1800}{60} \times 12.015 = 2.26 \text{ kW.}$ ✓	5 5.



Q	Question	Marks
Q2	$P = 5000 \text{ W}$ $N = 2500 \text{ RPM}$ $d = 0.13 \text{ m}$ $\mu = 0.4$ $\theta = 128^\circ \rightarrow 2.234 \text{ rad}$ $t_i = 250 \text{ N}$ a) $V = \omega r = \frac{2\pi N}{60} \times \frac{d}{2} = \frac{2\pi 2500}{60} \times \frac{0.13}{2} = 17.02 \text{ m/s}$ b) $F_1 + F_2 = \text{Constant} = 500 \text{ N}$ $\frac{F_1}{F_2} = e^{\mu \theta} = e^{0.4 \times 2.234}$ $F_1 = 2.44 F_2$ $F_1 = 2.44 (500 - F_1)$ $3.44 F_1 = 1221.97$ $F_1 = 355.22 \text{ N}$ $F_2 = 145.58 \text{ N}$ c) $P = v (F_1 - F_2) = 17.02 (355.22 - 145.58)$ $P = 3.568 \text{ kW}$ d) $n = \frac{5000}{3.568} = 1.401$ $\therefore 2 \text{ belts}$	2 4 2 2



Q	Question	Marks																				
Q3																						
a)	<table><tr><td></td><td>m</td><td>r</td><td>mr</td></tr><tr><td>A</td><td>0.87</td><td>80</td><td>69.6</td></tr><tr><td>B</td><td>0.55</td><td>120</td><td>66</td></tr><tr><td>C</td><td>0.58</td><td>95</td><td>55.1</td></tr><tr><td>D</td><td>m_D</td><td>40</td><td>$40m_D$</td></tr></table>		m	r	mr	A	0.87	80	69.6	B	0.55	120	66	C	0.58	95	55.1	D	m_D	40	$40m_D$	2
	m	r	mr																			
A	0.87	80	69.6																			
B	0.55	120	66																			
C	0.58	95	55.1																			
D	m_D	40	$40m_D$																			
b)	Appropriate Scale (1 mark) ✓ Sketch (1 mark) ✓  Accuracy 2 marks ✓	2																				
c)	$40m_D = 38.84$ ✓ $m_D = 0.971 \text{ kg}$ ✓	2																				
d)	Angle = 319.3° ✓ from horizontal.	2																				



Q	Question	Marks
Q4	Energy A E_A (min) B $E_A + 526$ (max) C $E_A + 321$ D $E_A + 366$ E $E_A + 181$ ✓✓ F $E_A + 229$ G $E_A + 32$ H $E_A + 42$ I E_A a) $N_2 = 2500 \text{ RPM}$ $N_1 = 2400 \text{ RPM}$ $\omega_2 = 261.8 \text{ rads}^{-1}$ $\omega_1 = 251.33 \text{ rads}^{-1}$ ✓ $\omega_m = 256.56 \text{ rads}^{-1}$ $\phi = \frac{\omega_2 - \omega_1}{\omega_m} = \frac{261.8 - 251.33}{256.56} = 0.0408$ ✓ b) ~~$I = \frac{BW}{\phi}$~~ Table = 2 marks. $BW = \text{max} - \text{min} = 526 \text{ S}$ ✓ c) $I = \frac{BW}{\phi \omega_m^2} = \frac{526}{0.0408 \times 256.56^2} = 0.196 \text{ kgm}^2$ ✓ d) $I = \frac{mr^2}{2}$ $m = \frac{2I}{r^2} = \frac{2 \times 0.196}{0.15^2} = 17.41 \text{ kg}$ ✓ $m = \rho V = \rho 2\pi r^2 t$ $t = \frac{m}{\rho 2\pi r^2} = \frac{17.41}{7850 \times 2\pi \times 0.15^2} = 15.7 \text{ mm}$ ✓	2 2 1 2 1 2



Q	Question	Marks
Q5.	$N_i = 2500 \text{ rpm}$ anti clock. $T_i = 20 \text{ Nm}$ $N = 0.85 \text{ \$/}$	
a)	a and b pair, and the c and pair must have same pitches as they are in mesh. ✓	1
b)	Output is anticlockwise $GR = \frac{64}{32} \times \frac{36}{24} = 3$ $N_2 = \frac{N_i}{GR} = \frac{2500}{3} = 833.33 \text{ rpm,}$	3
c)	$P_i = \frac{2\pi N_i}{60} \times T_i = \frac{2\pi \times 2500}{60} \times 20 = 5.24 \text{ kW}$ $P_o = N \times P_i = 0.85 \times 5.24 \times 10^3 = 4.45 \text{ kW.}$	3
d)	$T_o = \frac{60 P_o}{2\pi N_o} = \frac{60 \times 4.45 \times 10^3}{2\pi \times 833.33} = 51 \text{ Nm.}$ $T_i + T_o + T_h = 0$ $T_h = -T_i - T_o = 20 + 51 = +71 \text{ Nm}$ ↑ Clockwise.	3