NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

BACHELOR OF ENGINEERING (HONS) DEGREE INDUSTRIAL AND MANUFACTURING ENGINEERING

ENGINEERING DESIGN APPLICATIONS

TIE 2208

Second Semester Main Examination Paper

April/May 2015

This examination paper consists of 7 pages

Time Allowed: 3 hours

Total Marks: 100

INSTRUCTIONS AND INFORMATION

1. Answer any five (5) questions.
2. Each question carries 20 marks.
3. Make use of the attached formulae and tables as needed.
4. This paper contains seven (7) questions.

Question 1

(a) Suggest and explain any two characteristics desired for use as brake lining. [4]

(b) The brake shown in Figure Q1 (all dimensions in mm) has a coefficient of friction of 0.30 and is to operate using a maximum force *F* of 400 N. If the band width is 50 mm,

(i) Find the band tensions and the braking torque. [10]

(ii) Find the braking torque for anticlockwise rotation of the drum. [6]

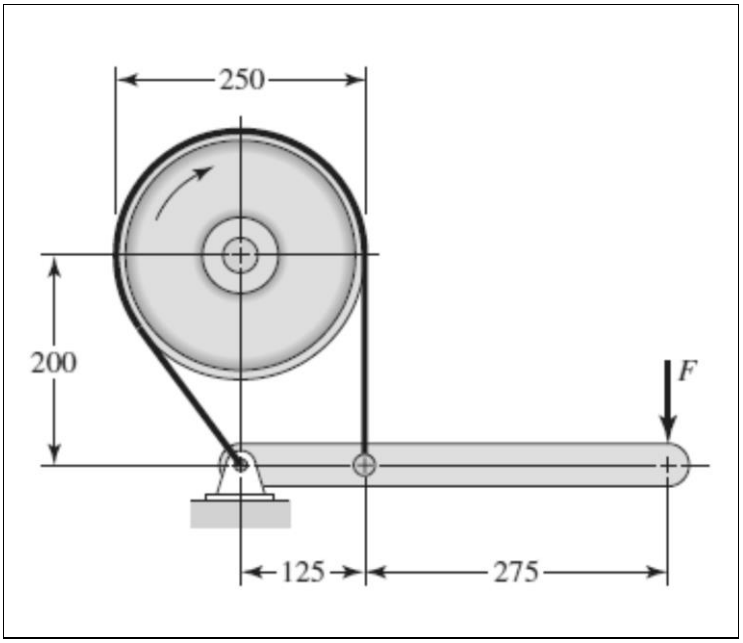

Figure Q1: Simple band brake

Question 2

(a) What is the primary function of a clutch? [1]

(b) A single plate clutch with contact surfaces on each side is required to transmit 110 kW at 1250 rev/min. The outer diameter of the contact surfaces is to be 300 mm and the coefficient of friction is 0.4. Assuming uniform pressure of 170 kN/m^2; determine the inner diameter of the friction surfaces. [8]

(c) Explain the uniform wear theory and use it to derive the expression for the torque transmitted by a cone clutch. [11]

Question 3

A workshop crane is lifting a load of 25 kN through a 6 × 19 wire rope and a hook. The weight of the hook is 15 kN. The rope drum diameter may be taken as 30 times the diameter of the rope. The load is to be lifted with an acceleration of 1 m/s^2. Calculate the diameter of the wire rope. Take a factor of safety of 6 and Young's modulus for the wire rope 80 GPa. The ultimate stress may be taken as 1800 MPa. The cross-sectional area of the wire rope may be taken as 0.38 times the square of the wire rope diameter. [20]

Question 4

An epicyclic train has a sun-wheel with 30 teeth and two planet wheels of 50 teeth, the latter meshing with the internal teeth of the fixed annulus. The input shaft, carrying the sun wheel, transmits 4kW at 300rev/min. The output shaft is connected to an arm which carries the planet wheels.

(a) What is the speed of the output shaft and the torque transmitted if the overall efficiency is 95%. [13]

(b) If the annulus is rotated independently, what should be its speed in order to make the output shaft rotate at 10rev/min? [7]

Question 5

A spring balance is to measure up to 1000 N over a scale of length (deflection) 80 mm. the scale is to be enclosed in a casing of 25 mm diameter. The approximate number of turns is 30. The modulus of rigidity is 85 GPa. For a spring index of 4.84,

(a) Calculate the diameter of the spring wire, [7]

(b) Calculate the mean diameter of the spring coil, [4]

(c) From the answers you gave in (a) and (b) above, is the design valid? Explain. [3]

(d) Calculate the maximum shear stress induced. [6]

Question 6

(a) With the aid of diagrams and equations, explain how the angle of articulation contributes to speed variation in chain drives and suggest how this variation can be minimized. [9]

(b) Design a roller chain is to transmit power from a 20 kW motor to a reciprocating pump. The pump is to operate continuously 24 hours per day. The speed of the motor is 600 r.p.m and that of the pump is 200 r.p.m. [11]

Question 7

(a) State any five the advantages of chain drives over belt drives? . [5]

(b) With the aid of diagrams, distinguish between co-axial and non-co-axial compound gear trains. [6]

(c) State the three (3) types of wire rope cores. [3]

(d) Distinguish between regular lay and lang lay wire ropes. [6]

End of Examination

List of Formulae

Chain sprocket outside diameter: $D_o = D + 0.8d_1$

Chain links: $K = \frac{T_1 + T_2}{2} + \frac{2C}{p} + \left[\frac{T_2 - T_1}{2\pi}\right]^2 \times \frac{p}{C}$

Chain centre distance: $C = \frac{p}{4}\left[K - \frac{T_1 + T_2}{2} + \sqrt{\left(K - \frac{T_1 + T_2}{2}\right)^2 - 8\left(\frac{T_2 - T_1}{2\pi}\right)^2}\right]$

Chain power: $P = \frac{W_B \times v}{n \times K_S}$

Chain power: $P = \frac{\sigma_b \times A \times v}{K_S}$

Rope bending stress: $\sigma_b = E_r \frac{d_w}{D}$

Rope direct stress: $\sigma_d = \frac{W + w}{A}$

Rope modulus of elasticity: $E_r = \frac{3}{8}E$

Equivalent bending load: $W_b = \sigma A_m = \frac{E_r d_w A_m}{D}$

Rope direct load: $W_d = W + w$

Rope load due to acceleration: $W_a = \frac{W + w}{g} \times a$

Spring deflection: $\delta = \frac{8WD^3 n}{Gd^4}$

Spring index: $C = \frac{D}{d}$

Shear stress factor: $K_S = 1 + \frac{1}{2C}$

Wahl's stress factor: $K = \frac{4C - 1}{4C - 4} + \frac{0.615}{C}$

Spring constant: $k = \frac{W}{\delta}$

Max shear stress in wire: $\tau = K \times \frac{8WD}{\pi d^3}$

Table 1: Load, lubrication and rating factors for chain drives

Load factor (K_1)	**Lubrication factor (K_2)**	**Rating factor (K_3)**
1, for constant load	0.8, for continuous lubrication	1, for 8 hours/day
1.25, for variable load with mild shock	1, for drop lubrication	1.25, for 16 hours/day
1.5 for heavy shock loads	1.5, for periodic lubrication	1.5, for continuous service

Table 2: Characteristics of roller chains

ISO Chain number	*Pitch (p) mm*	*Roller diameter (d_1) mm Maximum*	*Width between inner plates (b_1) mm Maximum*	*Transverse pitch (p_1) mm*	*Breaking load (kN) Minimum*		
					Simple	*Duplex*	*Triplex*
05 B	8.00	5.00	3.00	5.64	4.4	7.8	11.1
06 B	9.525	6.35	5.72	10.24	8.9	16.9	24.9
08 B	12.70	8.51	7.75	13.92	17.8	31.1	44.5
10 B	15.875	10.16	9.65	16.59	22.2	44.5	66.7
12 B	19.05	12.07	11.68	19.46	28.9	57.8	86.7
16 B	25.4	15.88	17.02	31.88	42.3	84.5	126.8
20 B	31.75	19.05	19.56	36.45	64.5	129	193.5
24 B	38.10	25.40	25.40	48.36	97.9	195.7	293.6
28 B	44.45	27.94	30.99	59.56	129	258	387
32 B	50.80	29.21	30.99	68.55	169	338	507.10
40 B	63.50	39.37	38.10	72.29	262.4	524.9	787.3
48 B	76.20	48.26	45.72	91.21	400.3	800.7	1201

Table 3: Factors of safety (n) for bush roller and silent chains

Type of chain	Pitch of chain (mm)	Speed of the sprocket pinion in r.p.m.								
		50	200	400	600	800	1000	1200	1600	2000
Bush roller chain	12 – 15	7	7.8	8.55	9.35	10.2	11	11.7	13.2	14.8
	20 – 25	7	8.2	9.35	10.3	11.7	12.9	14	16.3	–
	30 – 35	7	8.55	10.2	13.2	14.8	16.3	19.5	–	–
Silent chain	12.7 – 15.87	20	22.2	24.4	28.7	29.0	31.0	33.4	37.8	42.0
	19.05 – 25.4	20	23.4	26.7	30.0	33.4	36.8	40.0	46.5	53.5

Table 4: Power rating (in kW) of simple roller chains

Speed of smaller sprocket or pinion (r.p.m.)	Power (kW)				
	06 B	08 B	10 B	12 B	16 B
100	0.25	0.64	1.18	2.01	4.83
200	0.47	1.18	2.19	3.75	8.94
300	0.61	1.70	3.15	5.43	13.06
500	1.09	2.72	5.01	8.53	20.57
700	1.48	3.66	6.71	11.63	27.73
1000	2.03	5.09	8.97	15.65	34.89
1400	2.73	6.81	11.67	18.15	38.47
1800	3.44	8.10	13.03	19.85	–
2000	3.80	8.67	13.49	20.57	–

Table 5: Diameter of wire and area of wire rope

Type of wire rope	6 × 8	6 × 19	6 × 37	8 × 19
Wire diameter (d_w)	$0.106\ d$	$0.063\ d$	$0.045\ d$	$0.050\ d$
Area of wire rope (A)	$0.38\ d^2$	$0.38\ d^2$	$0.38\ d^2$	$0.35\ d^2$

Table 6: Steel Wire Ropes for General Engineering Purpose

Type of rope	*Nominal diameter (mm)*	*Average weight (N/m)*	*Average tensile strength (N)* *Tensile strength (N)*	
			1600–1750 MPa	*1750–1900 MPa*
6 × 19	8, 9, 10, 11, 12, 13, 14, 16, 18, 20, 22, 24, 26, 28, 32, 36, 38, 40	0.0375 d^2	540 d^2	590 d^2
6 × 37	8, 9, 10, 11, 12, 13, 14 16, 18, 20, 22, 24, 26, 28, 32, 36, 40, 44, 48, 52, 56	0.038 d^2	510 d^2	550 d^2

End of Examination Paper