NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Bachelor of Engineering Honours Degree Industrial and Manufacturing Engineering

2nd Semester Main Examination

COURSE	**: ENGINEERING DESIGN APPLICATIONS II**
CODE	**: TIE 2208**
DATE	**: MAY 2014**
DURATION	**: 3 HOURS**

INSTRUCTIONS AND INFORMATION FOR THE CANDIDATE

1. Answer any five (**5**) questions.
2. Each question carries 20 marks.
3. This paper contains seven **(7)** questions.
4. There are six **(6)** printed pages in this paper.
5. Make use of the attached lists of formulae and tables as needed.

QUESTION 1

(a) Name any two applications of wire ropes [2]

(b) Explain your understanding of the difference between drop and continuous lubrication as applied to chain drives. Cite appropriate examples. [6]

(c) Show how the pitch of a chain can contribute to speed variation during transmission. [7]

(d) Show the relationship between the diameter of the annulus and the sun and planet(s) for a simple gear epicyclic train. [5]

QUESTION 2

In the epicyclic gear shown in Figure Q2, the gear B has 120 teeth externally and 100 teeth internally. The driver A has 20 teeth and the arm E is connected to the driven shaft. Gear D has 60 teeth.

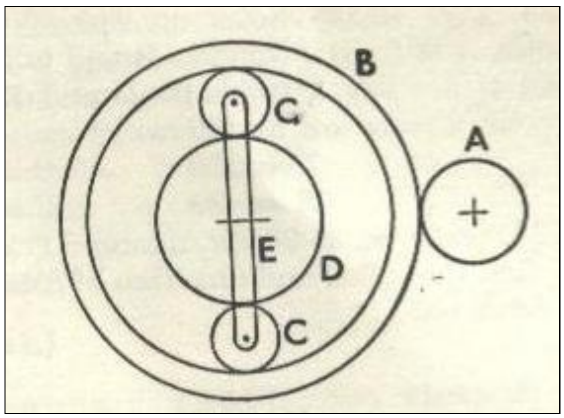

Figure Q2. Epicyclic gear

(a) If A revolves at +100 rev/min and D revolves at +27 rev/min, find the speed of the arm E. [11]

(b) If D is now fixed and A transmits a torque of 10 Nm at +100 rev/min, what will be the available torque at the arm E, assuming 93 per cent efficiency of transmission? [9]

QUESTION 3

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 500 r.p.m. and that of the pump 170 r.p.m. The factor of safety for the design is to be 15.

(a) Determine the pitch line velocity of the chain [11]

(b) Calculate the chain power on the basis of breaking load. [9]

QUESTION 4

Select a wire rope for a vertical mine hoist to lift a load of 55 kN from a depth of 300 m. A rope speed of 8.33 m/s is to be attained in 10 seconds. [20]

QUESTION 5

Design a helical compression spring for an operating load range of approximately 90 to 135 N. The deflection of the spring for the load range is 7.5 mm. Permissible shear stress for the spring material is 480 MPa and its modulus of rigidity is 80 GPa. Assume a spring index of 10. [20]

QUESTION 6

(a) A single plate clutch with both sides of the plate effective is required to transmit 25 kW at 1600 r.p.m. The outer diameter of the plate is limited to 300 mm and the intensity of pressure between the plates is not to exceed 0.07 N/mm^2. Assuming uniform wear and coefficient of friction 0.3, find the inner diameter of the plates and the axial force necessary to engage the clutch. [10]

(b) A soft cone clutch has a cone pitch angle of 10°, mean diameter of 300 mm and a face width of 100mm. If the coefficient of friction is 0.2 and has an average pressure of 0.07 N/mm^2 for a speed of 500r.p.m. Assuming uniform wear find:

(i) The force required to engage the clutch. [5]

(ii) The power that can be transmitted. [5]

QUESTION 7

(a) How does the function of a brake differ from that of a clutch? [2]

(b) List four characteristics of material that should be used for brake lining [4]

(c) A differential band brake is shown in Figure Q7. The diameter of the drum is 800 mm. The coefficient of friction between the band and the drum is 0.3 and the angle of embrace is 240°. When a force of 600 N is applied at the free end of the lever, find for the clockwise and anticlockwise rotation of the drum:

(i) The maximum and minimum forces in the band; [8]

(ii) The torque which can be applied by the brake [6]

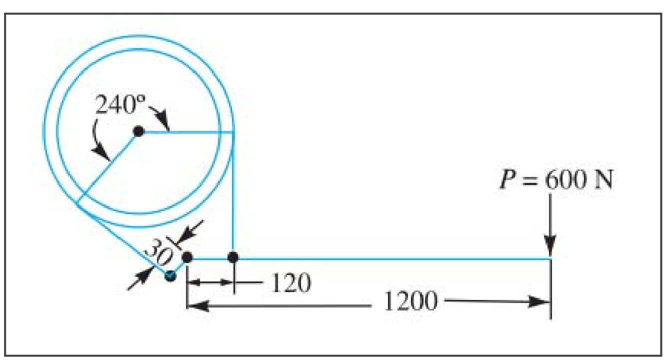

Fig Q7: Differential band brake (dimensions in mm)

List of Formulae and Tables

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

Load on chain driving side: $W = \frac{W_B}{n}$

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: $W_a = \frac{W + w}{g} \times a$

Mean spring diameter: $D = D_o - d$

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

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: Recommended number of teeth for smaller chain sprocket

Type of chain	*Number of teeth at velocity ratio*					
	1	2	3	4	5	6
Roller	31	27	25	23	21	17
Silent	40	35	31	27	23	19

Table 3: Power rating (in kW) for simple roller chain

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 4: Pitch characteristics of roller chains

Chain number	05B	06B	08B	10B	12B	16B	20B	24B	28B
Pitch (mm)	8.00	9.525	12.70	15.875	19.05	25.4	31.75	38.10	44.45

Table 5: Steel wire ropes for haulage purpose in mines

Type of rope	*Nominal diameter (mm)*	*Average weight (N/m)*	*Tensile strength (N)* *Tensile strength of wire*	
			1600 MPa	*1800 MPa*
6 × 7	8, 9, 10, 11, 12, 13, 14, 16 18, 19, 20, 21, 22, 24, 25 26, 27, 28, 29, 31, 35	$0.0347\ d^2$	$530\ d^2$	$600\ d^2$
6 × 19	13, 14, 16, 18, 19, 20, 21 22, 24, 25, 26, 28, 29, 32 35, 36, 38	$0.0363\ d^2$	$530\ d^2$	$595\ d^2$

Table 6: 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 7: Factors of safety for wire ropes

Application of wire rope	*Factor of safety*	*Application of wire rope*	*Factor of safety*
Track cables	4.2	Derricks	6
Guys	3.5	Haulage ropes	6
Mine hoists : Depths		Small electric and air hoists	7
upto 150 m	8	Over head and gantry cranes	6
300 – 600 m	7	Jib and pillar cranes	6
600 – 900 m	6	Hot ladle cranes	8
over 900 m	5	Slings	8
Miscellaneous hoists	5		

Table 8: Sheave diameters (D) for wire ropes

Type of wire rope	*Recommended sheave diameter (D)*		*Uses*
	Minimum sheave diameter	*Preferred sheave diameter*	
6 × 7	$42\ d$	$72\ d$	Mines, haulage tramways.
6 × 19	$30\ d$	$45\ d$	Hoisting rope.
	$60\ d$	$100\ d$	Cargo cranes, mine hoists
	$20\ d$	$30\ d$	Derricks, dredges, elevators, tramways, well drilling.
6 × 37	$18\ d$	$27\ d$	Cranes, high speed elevators and small shears.
8 × 19	$21\ d$	$31\ d$	Extra flexible hoisting rope.

End of Examination Paper