NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

BACHELOR OF ENGINEERING (HONS) INDUSTRIAL AND MANUFACTURING ENGINEERING

ENGINEERING DESIGN APPLICATIONS

EIE 2208

Main Examination Paper

March 2025

This examination paper consists of **7** printed pages

Time Allowed: **3 hours**

Total Marks: **100**

Special Requirements: **None**

Internal Examiner: **Mr. G. Chirinda**

External Examiner:

INSTRUCTIONS

1. Answer any four (4) questions
2. This paper contains six (6) questions

QUESTION	MARKS
1.	25
2.	25
3.	25
4.	25
5.	25
6.	25
TOTAL MARKS ATTAINABLE	**100**

Question 1

For a problem of your choice, outline the Engineering Design stages you would undertake to fulfil the stated need. The stages must include:

(a) Background [5]

(b) Problem statement [3]

(c) Aim [2]

(d) Objectives (state 4) [8]

(e) Methodology [7]

Question 2

(a) Discuss the application of rope drives in any two (2) industries of your choice. [5]

(b) Select a wire rope for a vertical mine hoist to lift a load of 50 kN from a depth of 150 metres. A rope speed of 250 metres per minute is to be attained in 10 seconds. Show all the steps. [20]

Question 3

Design a chain drive to actuate a compressor from 15 kW electric motor running at 1000 rpm, the compressor speed being 350 rpm. The minimum centre distance is 500 mm. The compressor operates 16 hours per day. The chain tension may be adjusted by shifting the motor on slides. [25]

Question 4

(a) A brake is a device by means of which artificial frictional resistance is applied to a moving machine member in order to retard or stop its motion. By means of well labelled diagrams, explain the principle of operation on brakes. [10]

(b) A differential band brake is shown in Fig Q4 (on page 3). It has an angle of contact of 225°. The band has a compressed woven lining and bears against a cast iron drum of 350 mm diameter. The brake is to sustain a torque of 350 Nm and the coefficient of friction between the band and the drum is 0.3.

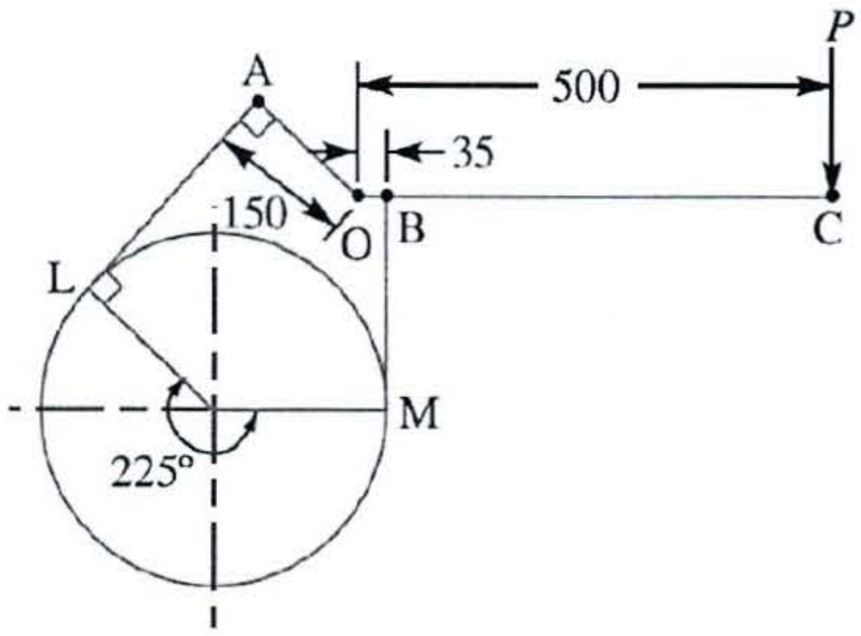

Fig Q4: A differential band brake

Find:

(i) The necessary force (**P**) for the clockwise rotation of the drum. [9]

(ii) The value of **OA** for the brake to be self-locking, when the drum rotates clockwise. [6]

Question 5

(a) Define a friction clutch and explain its role in transferring torque between the engine and the transmission system. [5]

(b) A cone clutch is to be designed to transmit 7.5 kW at 900 r.p.m. The cone has a face angle of 12°. The width of the face is half of the mean radius and the normal pressure between the contact faces is not to exceed 0.09 N/mm^2. Assuming uniform wear and the coefficient of friction between the contact faces as 0.2, find the main dimensions of the clutch and the axial force required to engage the clutch. [20]

Question 6

Describe the following types of conveyors, clearly outlining their working principles, applications, advantages, and limitations.

(a) Gravity conveyor [5]

(b) Bucket conveyor [5]

(c) Belt conveyor [5]

(d) Roller conveyor [5]

(e) Screw conveyor [5]

End of examination question paper

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

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: Number of teeth on the smaller sprocket

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

Table 4: 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 5: 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 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: 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