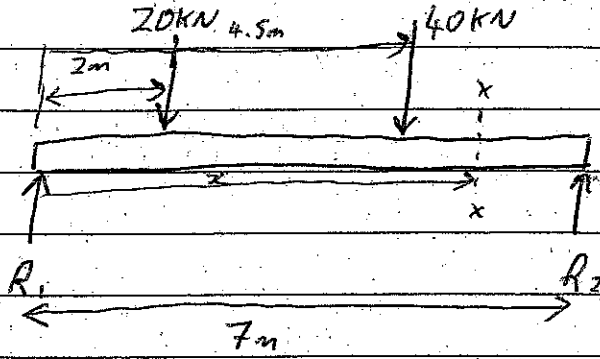




EXAMINATION SOLUTIONS : SESSION 200 /

Programme:	BENG MANUFACTURING SYSTEMS ENGINEERING	Year:	2
Module/Unit:	STRESS ANALYSIS & DYNAMICS		
Author:	KELVIN LAKE	Page:	1 of 17

Question No	Question	Marks
①		2
②	$\sum M_{R_2} = 0 \quad 7R_1 = 20 \times 5 + 40 \times 2.5$ $R_1 = 28.57 \text{ kN}$	1
	$EI \frac{d^2 y}{dx^2} = M$	1
	$\therefore EI \frac{d^2 y}{dx^2} = 28750x - 20,000(x-2) - 40,000(x-4.5)$	1
	$EI \frac{dy}{dx} = \frac{28750x^2}{2} - \frac{20,000(x-2)^2}{2} - \frac{40,000(x-4.5)^2}{2} + A \quad \text{①}$	1
	$EI y = \frac{28750x^3}{6} - \frac{20,000(x-2)^3}{6} - \frac{40,000(x-4.5)^3}{6} + Ax + B \quad \text{②}$	1

Continuation Sheet

Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	2 of 17
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Question No	Question	Marks
10		
cont.	BOUNDARY CONDITIONS.	
	WHEN $x=0$, $y=0$ ∴ FROM ② $B=0$	1
	WHEN $x=7$, $y=0$	1
	$0 = \frac{28750x^3}{6} - \frac{20000(x-2)^3}{6} - \frac{40,000(x-4.5)^3}{6} + Ax$	
	$= \frac{28750 \times 7^3}{6} - \frac{20,000 \times 5^3}{6} - \frac{40,000 \times 2.5^3}{6} + 7A$	
	$\therefore A = -234792 + 59523.8 + 14880.95$	
	$= -160,387$	2
	∴ FROM ②	
	$EI_y = \frac{28750x^3}{6} - \frac{20,000(x-2)^3}{6} - \frac{40,000(x-4.5)^3}{6} - 160387x$	

Continuation Sheet

Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	3 of 17
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Question No.	Question	Marks
Q1 cont..	AT MIDPOINT : $x = 3.5$	1
	$\therefore EI_y = \frac{28750 \times 3.5^3}{6} - \frac{20000 \times 1.5^3}{6} - 160387 \times 3.5$ $= 205443 - 11250 - 561355$ $= 205443 - 367162$	
	IF $y = -8 \text{ mm}$	
	$EI = \frac{-367162}{-8 \times 10^{-3}}$ $= \underline{\underline{45.9 \text{ MPa}}}$	3

Continuation Sheet

Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	4 of 17
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Question No	Question	Marks
① ⑥	$EI = 45.9 \times 10^6$	
	$\therefore I = \frac{45.9 \times 10^6}{200 \times 10^9}$	
	$= \underline{2.295 \times 10^{-4} \text{ m}^4}$	2
②	$I = 2.295 \times 10^{-4} \text{ m}^4$	
	$= (2.295 \times 10^{-4}) \times 10^8$	
	$= \underline{22,950 \text{ cm}^4}$	1
	LIGHTEST BEAM IS $D \times B = 457.2 \times 151.9$	
	$I_{xx} = 28,577 \text{ cm}^4$	
		1
	WEIGHT = 67 Kg/m	
	$\therefore$ WEIGHT OF BEAM IS $7 \times 67 = \underline{469 \text{ Kg}}$	1
		/
		20

Continuation Sheet

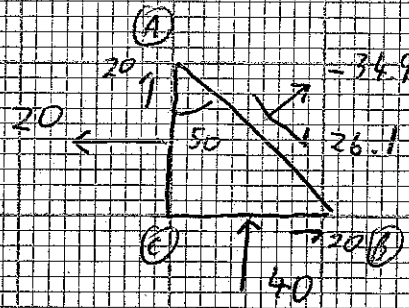
Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	5 of 17
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Question No	Question	Marks
(2a)	$\theta = 90 - 40 = 50^\circ$ $\sigma_x = 20 \text{ MPa}$ $\sigma_y = -40 \text{ MPa}$ $\tau_{xy} = -20 \text{ MPa}$	1
	$\therefore \sigma_\theta = \frac{1}{2}(\sigma_x + \sigma_y) + \frac{1}{2}(\sigma_x - \sigma_y) \cos 2\theta + \tau_{xy} \sin 2\theta$	
	$= \frac{1}{2}(20 - 40) + \frac{1}{2}(20 + 40) \cos 100 - 20 \sin 100$	
	$= \underline{\underline{-34.9 \text{ MPa}}}$	2
	$\tau_\theta = \frac{1}{2}(\sigma_x - \sigma_y) \sin 2\theta - \tau_{xy} \cos 2\theta$	
	$= \frac{1}{2}(20 + 40) \sin 100 + 20 \cos 100$	
	$= \underline{\underline{26.1 \text{ MPa}}}$	2
(b)	$\sigma_1 = \frac{1}{2} \left[(\sigma_x + \sigma_y) + \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2} \right]$	
	$= \frac{1}{2} \left[(-20 - 40) + \sqrt{(20 + 40)^2 + 4(-20)^2} \right]$	
	$= \frac{1}{2} (-20 + \sqrt{3600 + 1600})$	
	$= \underline{\underline{26.06 \text{ MPa}}}$	2

Continuation Sheet

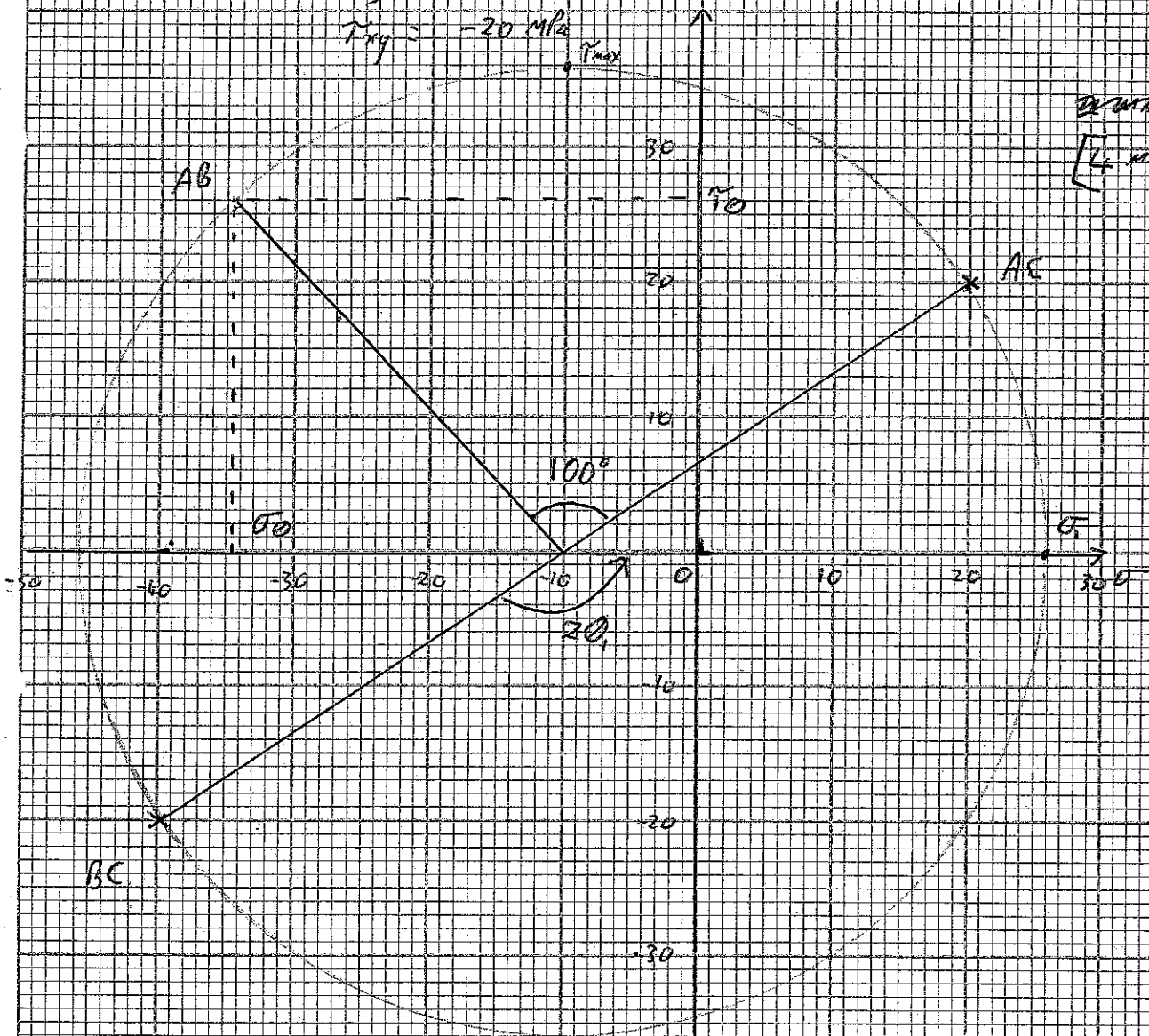
Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	6 of 17
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Question No	Question	Marks
(20)	$\tau_{max} = \frac{1}{2} \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$ $= \frac{1}{2} \sqrt{(20 + 40)^2 + 4(-20)^2}$ $= \underline{\underline{36.06 \text{ MPa}}}$	2
(d)	SEE MOHR'S CIRCLE OVER PAGE.	(4)
	TAKING MEASUREMENTS : $\sigma_0 \approx \underline{\underline{-34.5 \text{ MPa}}}$	1 ~~1/4~~
	$\tau_0 \approx \underline{\underline{26 \text{ MPa}}}$	1 ~~1/4~~
	$\sigma_1 \approx \underline{\underline{26 \text{ MPa}}}$	1 ~~1/4~~
	$\tau_{max} \approx \underline{\underline{36 \text{ MPa}}}$	1 ~~1/4~~
(e)	BY MEASUREMENT $2\theta_1 \approx 146^\circ$ $\therefore \theta_1 \approx \underline{\underline{73^\circ}}$	2
(f)	(d) IS APPROXIMATE AS THEY ARE MEASURED.	1
		/
		20



Plot: AC: $\sigma_x = 20 \text{ MPa}$
 $\tau_{xy} = 20 \text{ MPa}$

BC: $\sigma_y = -40 \text{ MPa}$
 $\tau_{xy} = -20 \text{ MPa}$



2 MARKS
 [4 MARKS]

Continuation Sheet

Module/Unit:	STRIPS ANALYSIS & DYNAMICS	Page:	8 of 17
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Question No	Question	Marks
(3) (a)	$D_{\text{ANNULUS}} = D_{\text{SUN}} + 2 D_{\text{PLANETS}} \quad (D = \text{p.c.d.})$	
	$m T_A = m T_S + 2 m T_P \quad (\text{SINCE } D = m \times T, \quad m = \text{MODULE})$ $T = \text{TEETH}$	
	SINCE MODULE MUST BE SAME IN ORDER FOR THE TEETH TO MESH:	
	$T_A = T_S + 2 T_P$	
	GEARS A, B & D : $T_D = T_A + 2 T_B$ $= 33 + 2 \times 24$ $= 81 \text{ TEETH}$	1
	GEARS E, C & F : $T_F = T_E + 2 T_C$ $\therefore T_E = T_F - 2 T_C$ $= 70 - 2 \times 20$ $= 30 \text{ TEETH}$	1

Continuation Sheet

Module/Unit:

STRESS ANALYSIS & DYNAMICS

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Question No	Question	Marks																												
(3)(a)																														
cont...	TABLE OF REVS																													
	<table><tr><td></td><td>SHAFT Y</td><td>FIXED AXIS F</td><td>PLANET C</td><td>D, E</td><td>PLANET B</td><td>SHAFT X (SUN A)</td></tr><tr><td>① ROTATE 'ALL' +1 REV</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td></tr><tr><td>② FIX Y (CARRIERS) AND ROTATE F-1 REV (CARRIER EFFECT ON OTHERS)</td><td>0</td><td>-1</td><td>$-\frac{T_F}{T_C}$ = $-\frac{70}{20}$</td><td>$+\frac{T_F}{T_E}$ = $\frac{70}{30}$</td><td>$\frac{T_F}{T_E} \times \frac{T_D}{T_B}$ $= \frac{70}{30} \times \frac{81}{24}$</td><td>$-\frac{T_B}{T_A} \times \frac{T_F}{T_E} \times \frac{T_D}{T_B}$ $= -\frac{24}{33} \times \frac{70}{30} \times \frac{81}{24}$</td></tr><tr><td>③ 400 IMPS (1)+(2)</td><td>1</td><td>0</td><td>$1 - \frac{70}{20}$</td><td>$1 + \frac{70}{30}$</td><td>$1 + \frac{70}{30} \times \frac{81}{24}$</td><td>$1 - \frac{70 \times 81}{33 \times 30}$</td></tr></table>		SHAFT Y	FIXED AXIS F	PLANET C	D, E	PLANET B	SHAFT X (SUN A)	① ROTATE 'ALL' +1 REV	+1	+1	+1	+1	+1	+1	② FIX Y (CARRIERS) AND ROTATE F-1 REV (CARRIER EFFECT ON OTHERS)	0	-1	$-\frac{T_F}{T_C}$ = $-\frac{70}{20}$	$+\frac{T_F}{T_E}$ = $\frac{70}{30}$	$\frac{T_F}{T_E} \times \frac{T_D}{T_B}$ $= \frac{70}{30} \times \frac{81}{24}$	$-\frac{T_B}{T_A} \times \frac{T_F}{T_E} \times \frac{T_D}{T_B}$ $= -\frac{24}{33} \times \frac{70}{30} \times \frac{81}{24}$	③ 400 IMPS (1)+(2)	1	0	$1 - \frac{70}{20}$	$1 + \frac{70}{30}$	$1 + \frac{70}{30} \times \frac{81}{24}$	$1 - \frac{70 \times 81}{33 \times 30}$	6
	SHAFT Y	FIXED AXIS F	PLANET C	D, E	PLANET B	SHAFT X (SUN A)																								
① ROTATE 'ALL' +1 REV	+1	+1	+1	+1	+1	+1																								
② FIX Y (CARRIERS) AND ROTATE F-1 REV (CARRIER EFFECT ON OTHERS)	0	-1	$-\frac{T_F}{T_C}$ = $-\frac{70}{20}$	$+\frac{T_F}{T_E}$ = $\frac{70}{30}$	$\frac{T_F}{T_E} \times \frac{T_D}{T_B}$ $= \frac{70}{30} \times \frac{81}{24}$	$-\frac{T_B}{T_A} \times \frac{T_F}{T_E} \times \frac{T_D}{T_B}$ $= -\frac{24}{33} \times \frac{70}{30} \times \frac{81}{24}$																								
③ 400 IMPS (1)+(2)	1	0	$1 - \frac{70}{20}$	$1 + \frac{70}{30}$	$1 + \frac{70}{30} \times \frac{81}{24}$	$1 - \frac{70 \times 81}{33 \times 30}$																								
	HENCE OVERALL GEAR RATIO $G = \frac{N_x}{N_y} = \frac{N_A}{N_{CARRIER}}$																													
	$G = \frac{1 - \frac{70 \times 81}{33 \times 30}}{1}$																													
	$= 1 - 5.73$																													
	$= -4.73$	2																												
	(REVERSE SENSE TO INPUT)																													

Continuation Sheet

Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	10 of 17
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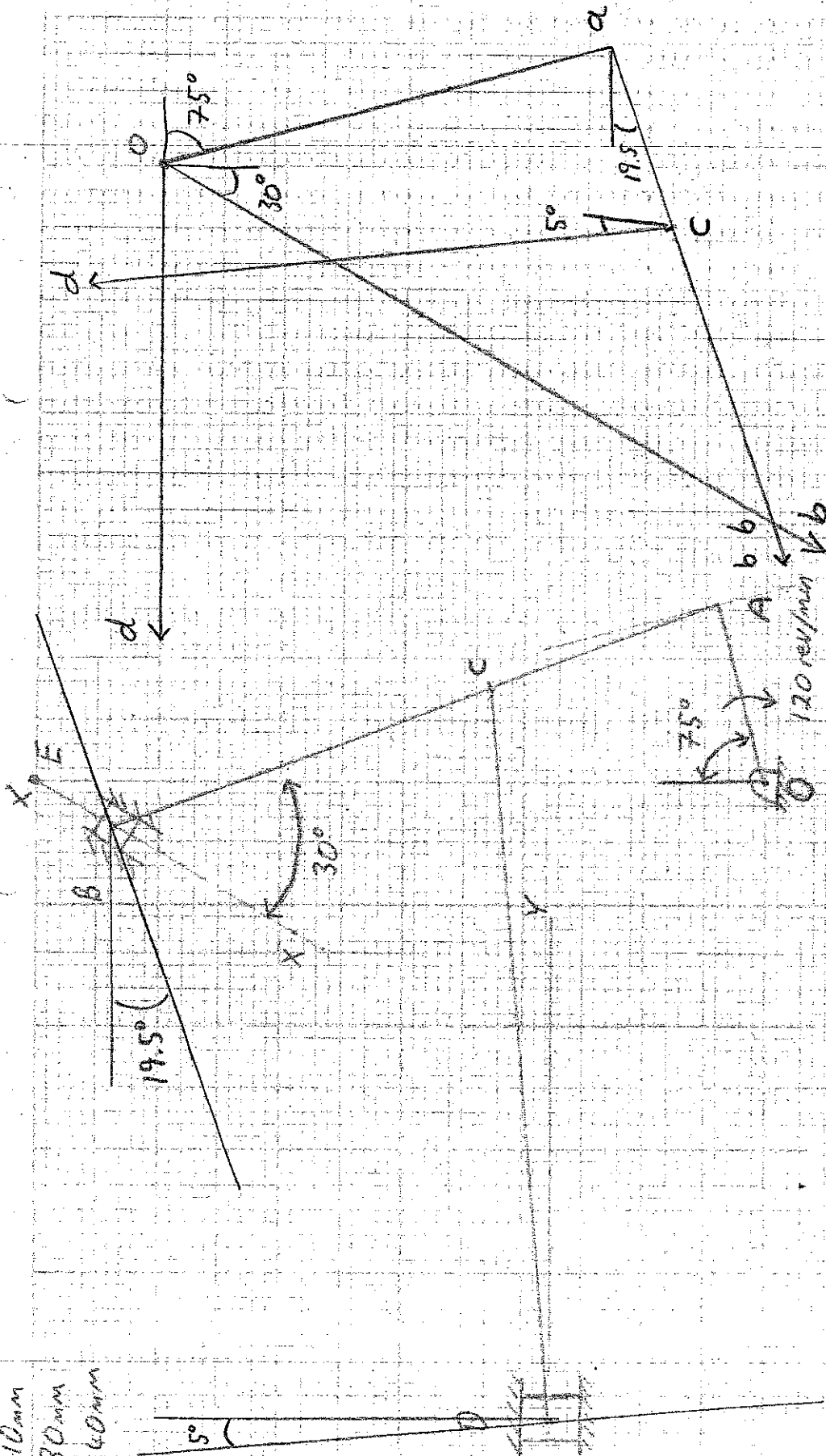
Question No.	Question	Marks
Q4 (3b)	SEE DIAGRAM ON NEXT PAGE (12) CONSTRUCTION IS AS FOLLOWS: ~~CONSTRUCTION~~ (DESCRIPTION NOT NEEDED)	(2)
1)	VELOCITY OF A RELATIVE TO O $V_{AO} = OA \times \omega_B$ $= 60 \times 10^{-3} \times 120 \times 2\pi$ $= 0.754 \text{ m/s}$	
	HENCE $\vec{OA}$ DRAWN $0.754 \pm 7.54 \text{ cm}$ LONG AT 75° FROM HORIZONTAL.	
2) SLIDER B	• SLIDER B CONSTRAINED TO MOVE ALONG AXIS 30° TO O $\therefore \vec{OB}$ DRAWN WITH INDETERMINATE LENGTH.	1
	• V_{BA} (TANGENTIAL OF B RELATIVE TO A): ANGLE OF TANGENT ^{FROM HORIZ} MEASURED FROM DIAGRAM = 19.5°	
	$\therefore \vec{AB}$ DRAWN 19.5° FROM HORIZONTAL, WITH INTERSECTION WITH $\vec{OB}$ FIXING B.	1
3) PIN JOINT C	• IS POSITIONED SUCH THAT $\frac{ac}{ab} = \frac{AC}{AB} = \frac{80}{210} = 0.38$ $\therefore ac = 0.38 ab$	
	BY MEASUREMENT $ab = 82 \text{ mm} \therefore ac = 31.2 \text{ mm}$	1

Continuation Sheet

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Question No.	Question	Marks
Cont... ③	SLIDER D	
	• SLIDER D CONSTRAINED TO MOVE ALONG HORIZONTAL AXIS ~~at~~ TO O $\therefore \vec{od}$ DRAWN WITH INDETERMINATE LENGTH.	1
	• V_{dc} (TANGENTIAL OF D RELATIVE TO A) : ANGLE OF TANGENT FROM VERTICAL MEASURED FROM DIAGRAM = 5° $\therefore \vec{cd}$ DRAWN 5° FROM VERTICAL, WITH INTERSECTION WITH <u>$\vec{od}$</u> FINISHED	1
	VELOCITY DIAGRAM COMPLETE!	
	• SLIDER B : $\vec{ob}$ (MEASURED) = 11.7 cm $\therefore V_{ob} = 11.7 \times 0.1$ $= \underline{\underline{1.17 \text{ m/s}}}$	1
	30° 'DOWNWARD AND LEFT' IN SENSE $O \rightarrow b$	
	• SLIDER D : $\vec{od}$ (MEASURED) = 1.9 cm $\therefore V_{od} = 1.9 \times 0.1$ $= \underline{\underline{0.19 \text{ m/s}}}$	1
	TO 'LEFT' IN SENSE $O \rightarrow d$	
		/20

- 1 = 60mm
- 2 = 210mm
- 3 = 80mm
- 4 = 260mm

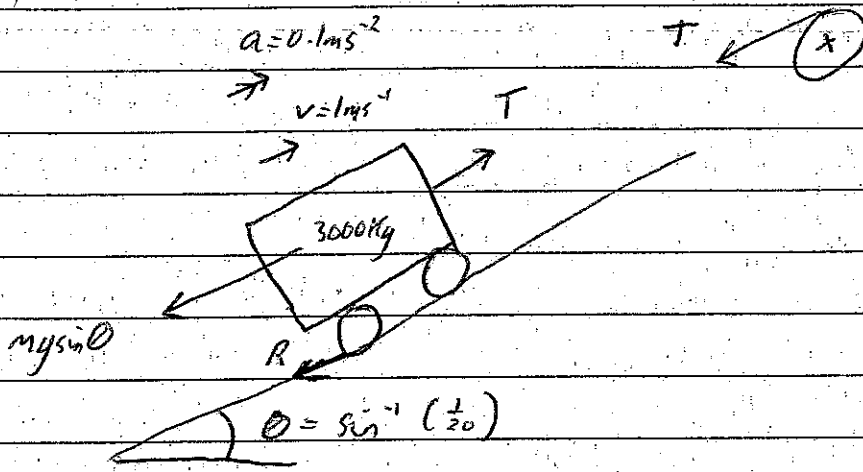


[10 MARKS TOTAL]

Continuation Sheet

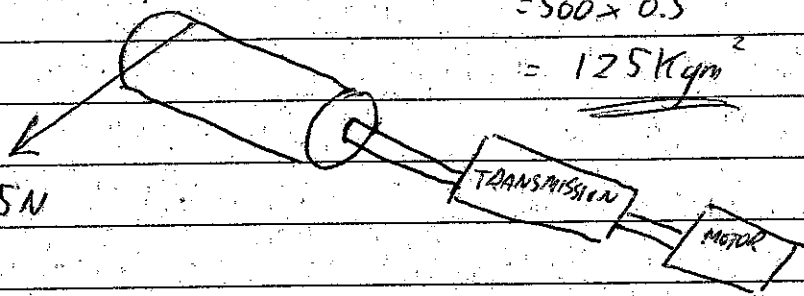
Module/Unit: STATICS ANALYSIS & DYNAMICS

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Question No.	Question	Marks
(4a)	 $a = 0.1 \text{ ms}^{-2}$ $v = 1 \text{ ms}^{-1}$ 3000 kg $mg \sin \theta$ R T $\theta = \sin^{-1} \left(\frac{1}{20} \right)$ NET ACCELERATING FORCE $F_{\text{NET}} = T - (R + mg \sin \theta)$ $\therefore ma = T - (R + mg \sin \theta)$ $3000 \times 0.1 = T - (1000 + 3000 \times 9.81 \left(\frac{1}{20} \right))$ $300 = T - (1000 + 1471.5)$ $T = 300 + 2471.5$ $T = \underline{\underline{2771.5 \text{ N}}}$	1

Continuation Sheet

Module/Unit	STRESS ANALYSIS & DYNAMICS	Page:	14 of 17
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Question No	Question	Marks
(4a) cont.	CONSIDER WINDING DRUM $\phi = 1.2m$ $I_0 = M_b \times k_G^2$ $= 500 \times 0.5^2$ $= 125 kgm^2$  $T = 2771.5N$	1
	TORQUE FROM ROPE $= T \times r_0$ $= 2771.5 \times 0.6$ $= 1662.9 Nm$	1
	ANGULAR ACC ⁿ OF DRUM $\alpha = \frac{a}{r_0} = \frac{0.1}{0.6} = 0.167 rad/s^2$	1
	TORQUE TO ACC DRUM $= I_0 \alpha = 125 \times 0.167 = 20.8 Nm$	1
	$\therefore$ TOTAL TORQUE $= 1662.9 + 20.8 = 1683.7 Nm$	1
	ANGULAR SPEED OF DRUM $\omega_0 = \frac{v}{r_0} = \frac{1}{0.6} = 1.67 rad/s$	1
	$\therefore$ POWER AT DRUM $=$ TORQUE $\times$ ω_0 $= 1683.7 \times 1.67$ $= 2811.8 W$	1
	TRANSMISSION IS 85% EFFICIENT $\therefore$ INPUT POWER $= 2811.8 = 3308 W$	1

Continuation Sheet

Module/Unit:

STRESS ANALYSIS & DYNAMICS

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Question No.	Question	Marks
(4 b) (1)	$t_0 = 0$ $t_1 = 15$ $t_2 = 30$ $t_3 = 31.8$	2
	$t_1: \quad v = u + at$ $\therefore t_1 = \frac{v-u}{a} = \frac{1.5-0}{0.1} = \underline{\underline{15 \text{ sec}}}$	1
	$t_2: \quad t_2 = t_1 + 15 = \underline{\underline{30 \text{ sec}}}$	1
	$t_3: \quad \text{DECELERATING FORCE: } F = 1000 + mg \sin \theta$ $= 1000 + 3000 \times 9.81 \left(\frac{1}{20}\right)$ $= \underline{\underline{2471.5 \text{ N}}}$	1
	$\therefore F = ma \therefore a = \frac{F}{m} = \frac{2471.5}{3000} = 0.82 \text{ ms}^{-2}$	
	$t = \frac{v-u}{a} = \frac{0-1.5}{-0.82} = \underline{\underline{1.82 \text{ seconds}}}$	
	$\therefore t_3 = t_2 + 1.8 = \underline{\underline{31.8 \text{ sec}}}$	1

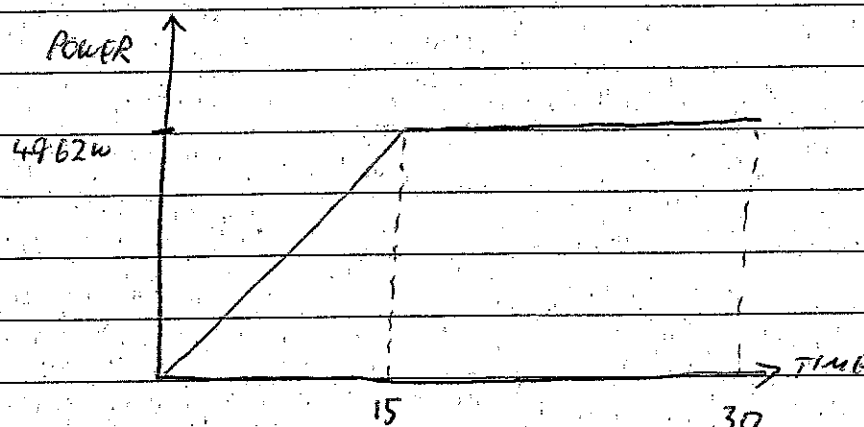
Continuation Sheet

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Question No	Question	Marks
4b (i)	$= \text{AREA UNDER GRAPH}$	
ans:	$\therefore \text{TOTAL DISTANCE} = \frac{15 \times 1.5}{2} + 15 \times 1.5 + \frac{1.8 \times 1.5}{2}$	
	$= 11.25 + 22.5 + 1.35$	
	$= \underline{\underline{35.1m}}$	2
(ii)	$v = 1$ $a = 0.1$ $\therefore t = \frac{v-u}{a} = \frac{1-0}{0.1} = \underline{\underline{10 \text{ sec}}}$	
	(x MARKED ON GRAPH)	1
(b)	~~Ques 4b (ii) is wrong~~	

Continuation Sheet

Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	17 of 17
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Question No.	Question	Marks
(46)	POWER OUTPUT FROM MOTOR:	
(IV)	 FROM (a) $3308 \text{ W} = 1 \text{ ms}^{-1}$ LINEAR RELATIONSHIP $\therefore 1.5 \text{ ms}^{-1} = 3308 \times 1.5$ $= 4962 \text{ W}$ POWER = $\frac{\text{ENERGY}}{\text{TIME}}$ $\therefore \text{ENERGY} = \text{POWER} \times \text{TIME} = \text{AREA UNDER GRAPH}$ $= \frac{4962 \times 15}{2} + 15 \times 4962$ $= 37215 + 74430$ $= 111645 \text{ J}$ $= \underline{\underline{111.6 \text{ KJ}}}$	1
		1
		20

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