

Stress analysis and dynamics

1.

- a. A 7m long simply supported beam that is supported at either end has a vertical downwards load of 20kN 2m from the lefthand end and another vertical downwards load of 40kN 4.5m from the lefthand end. Using “slope and deflection of beams theory” calculate the minimum flexural stiffness required to limit the central deflection to 8mm neglecting the weight of the beam.

[15 Marks]

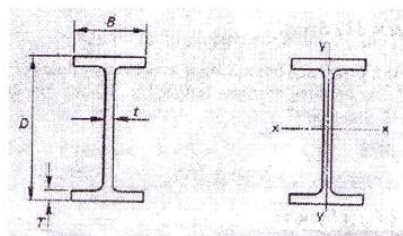
- b. Assuming the beam is made of steel ($E = 200\text{GPa}$), what would the minimum second moment of area be?

[2 Marks]

- c. Hence choose a suitable beam from below assuming the beam is loaded about XX. What would the mass of this beam be over the span required?

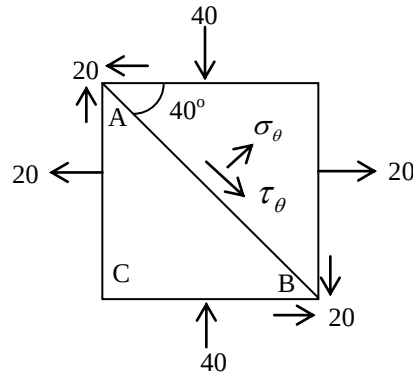
[3 Marks]

Size D x B (mm)	Mass per metre (kg)	Thickness		I_{xx} (cm^4)	I_{yy} (cm^4)
		Web, t (mm)	Flange, T (mm)		
910.3 x 304.1	222	15.9	23.9	375924	11223
840.7 x 292.4	194	14.7	21.7	279450	9069
762 x 266.7	173	14.3	21.6	205177	6846
677.9 x 253.0	125	11.7	16.2	118003	4379
617.5 x 307.0	113	14.1	23.6	151631	11412
533.1 x 209.3	92	10.2	15.6	55353	2392
467.4 x 192.8	98	11.4	19.6	45717	2343
457.2 x 151.9	67	9.1	15	28577	878
402.3 x 142.4	46	6.9	11.2	15647	539
364 x 173.2	67	9.1	15.7	19522	1362
352.8 x 126.0	39	6.5	10.7	10087	357
310.9 x 166.8	54	7.7	13.7	11710	1061
312.7 x 102.4	33	6.6	10.8	6487	193
254 x 101.6	22	5.8	6.8	2867	120
203.2 x 133.4	25	5.8	7.8	2356	310



2.

- a. Consider the below stressed element. Determine what the normal and shear stresses on plane AB are using analytical methods.



All stresses are in MN/m^2

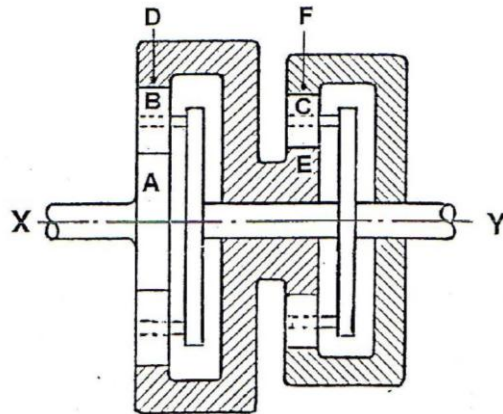
[5 Marks]

- b. What is the maximum principal stress on the above element?
[2 Marks]
- c. What is the maximum shear stress on the above element?
[2 Marks]
- d. Confirm your answers to a-c above using graphical methods on the graph paper attached to this exam paper. Make sure to mark clearly on the diagram any measurements that you take.
[8 Marks]
- e. Using graphical methods, at what angle when measured anti-clockwise from plane BC does the maximum principal plane act?
[2 Marks]
- f. Comment on the results from a-c when compared to those obtained in d.
[1 Mark]

3.

- a. The figure below shows a part-sectioned view of a compound epicyclic gear train. Sun gear A is keyed to input shaft X, whilst planet gears B and C are carried on 'spider arms' mounted on output shaft Y, which is co-axial with input shaft X. Annulus gear D is compounded with sun gear E, and freely rotates on the same axis as output shaft Y, whilst the second annulus gear F is fixed. Known teeth numbers for most of the gears are shown alongside the figure. In order to be compatible with the other gears, determine the number of teeth on the compound gears D and E, and thus calculate the overall ratio for the gear train.

[10 Marks]



Teeth Numbers

Gear A = 33

Gear B = 24

Gear C = 20

Gear D = ?

Gear E = ?

Gear F = 70

- b. Attached to this exam paper is a 'line diagram' of a mechanism, which has been drawn to scale. The crank OA rotates in a clockwise direction at 102 rev/min, the block B moves along the axis XX which is 30° to the vertical. The block D moves along the horizontal axis YY. AB and CD are connected by a pin-joint at C. AB = 210mm, AC = 80mm and CD = 240mm.

In the space on the right side of the worksheet, construct the velocity diagram for the mechanism at the instant shown, and hence determine the magnitude and sense of the instantaneous velocity of the sliders B and D. A scale of 1cm = 0.1m/s should be used, and point O has been located, from where your construction should begin. Make sure any lengths or angles measured during construction are clearly marked.

[10 Marks]

4.

- a. A 3 ton truck is hauled up an incline of 1 in 20 (5%) by a rope which is parallel to the incline and which winds onto a 1.2m diameter winding drum at the top of the incline. The winding drum has a mass of 0.5 tons and a radius of gyration of 0.5m, and is coupled through a transmission unit to an electrical drive motor. The mechanical efficiency of the transmission unit is 85% and the frictional resistance to motion is 1.0kN at all times. If the velocity and acceleration of the truck at a particular instance are 1m/s and 0.1ms^{-2} respectively, calculate the corresponding power output from the electric motor. Neglect the weight of the rope throughout your analysis.

[10 Marks]

- b. The motor in (a) is used to haul the truck from rest at time zero, up the incline until it reaches a speed of 1.5ms^{-2} . The power output from the motor is then reduced to maintain this velocity for a further 15 seconds, at which time the motor is switched off and the truck is allowed to coast.

- i. Draw a velocity v time graph showing the motion of the truck from time zero until it is just about to start rolling back down the hill.

[6 Marks]

- ii. How Far will the truck have travelled before it starts rolling back down the hill?

[1 Mark]

- iii. Mark on the graph the point there the power of the motor was calculated in (a).

[1 Mark]

- iv. Using your answer to (a) and assuming a linear relationship between power (J/sec) and velocity (m/s) calculate the total energy output from the electric motor.

[2 Marks]