Assignment brief
Learning Outcomes and Assessment Criteria 2020-21

Sample number: 2

Unit Title: Mechanical Science – XH1/3/AA/01G

Overview of assessment task

Answer questions 1-5.

Learning outcomes and assessment criteria

Learning Outcomes	Assessment Criteria
2. Be able to use practical investigations and calculations to demonstrate the principle of moments and system equilibrium, with reference to working situations	2.1. Demonstrate, by calculation, the equilibrium of uniform, simply supported beams and other simple force systems 2.2. Determine the reactions due to concentrated and uniformly distributed loads
3. Understand the results of tests to show the effects of shear force on, and the application of shear stress, to engineering materials	3.1. Analyse the results of tests carried out on engineering materials to determine: (a) the Shear Modulus and Young's Modulus (b) the effect of torsion and double shear
5. Be able to construct shear force and bending moment diagrams and explain their significance	5.1. Demonstrate by calculation: (a) simply supported beams and cantilevers (b) point and uniformly distributed loads and combined loading (c) the point of contra flexure 5.2. Determine the magnitude and position of the maximum bending moment for different load configurations

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Unit title: Mechanical Science - XH1/3/AA/01G

GD 1: Understanding of the subject

Merit	Distinction
The student, student's work or performance: a. demonstrates a **very good** grasp of the relevant knowledge base	The student, student's work or performance: a. demonstrates an **excellent** grasp of the relevant knowledge base

GD 3: Application of skills

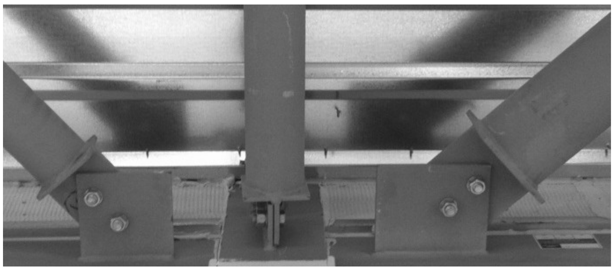
Merit	Distinction
The student, student's work or performance: a. **generally** selects appropriate • methods	The student, student's work or performance: a. **consistently** selects appropriate • methods

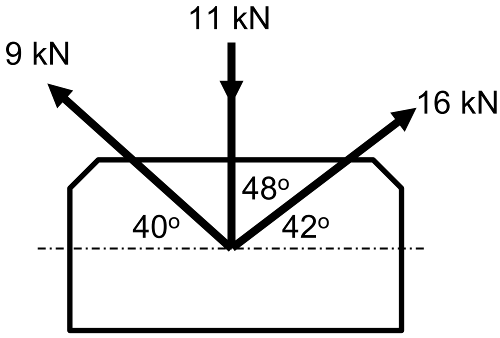
GD 7: Quality

Merit	Distinction
The student, student's work or performance: c. taken as a whole, demonstrates a **very good** response to the demands of the brief/assignment	The student, student's work or performance: c. taken as a whole, demonstrates an **excellent** response to the demands of the brief/assignment

Question 1

The image and figure below illustrates the loads on a supporting plate forming a joint within XXXX College's roof truss structure. Demonstrate by calculation the magnitude of the resultant and equilibrant force and determine their angle relative to the horizontal plane.

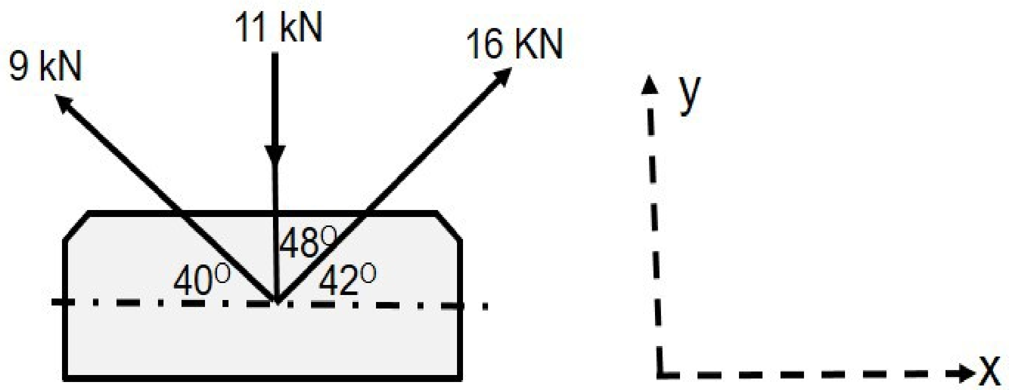




ANSWER

Question 1

Given:



$R = R_x + R_y$

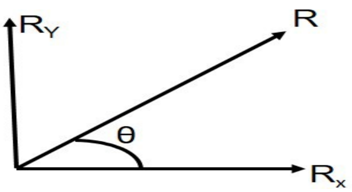
$R_x = \sum R_x = 16\cos42^\circ - 9\cos40^\circ = 11.89 - 6.89 = 5\text{kN}$

$R_y = \sum R_y = 16\sin42^\circ + 9\sin40^\circ - 11 = 5.49\text{kN}$

$R^2 = R_x^2 + R_y^2$

$R = 7.4\text{kN}$

$\theta = \tan^{-1}\left(\frac{5.49}{5}\right) = \mathbf{47.67}^\circ$

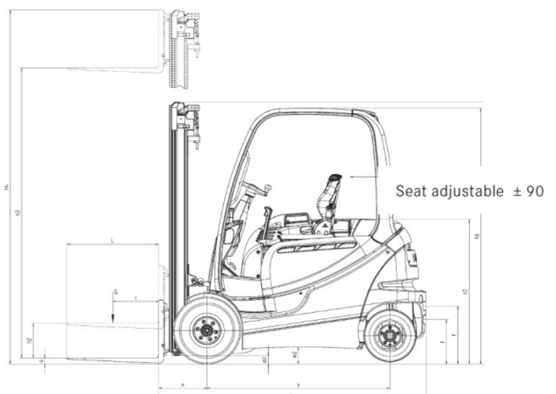


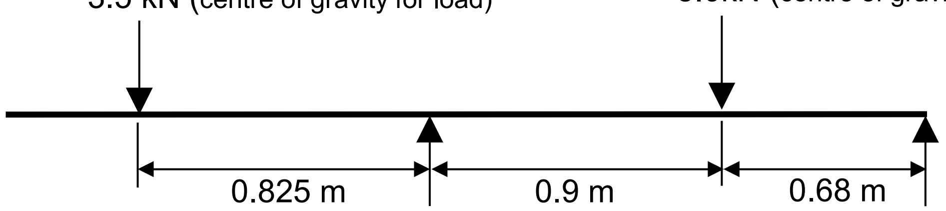
Question 2:

The beam shown below represents the forces and support reactions experienced within a typical fork-lift truck as illustrated.

Algebraically state the three conditions in a two-dimensional plane required for static equilibrium.

Calculate the reaction forces at each wheel and include a checksum to confirm your calculations.





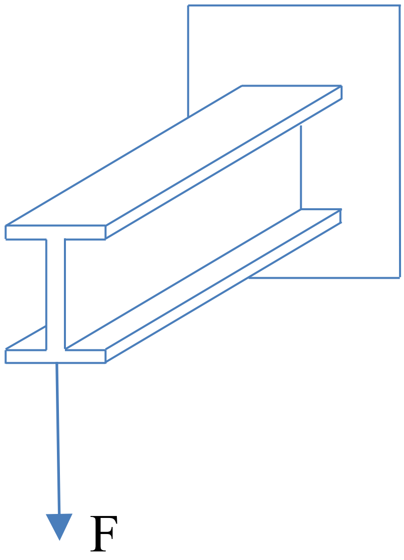
ANSWER
<u>**Question 2:**</u>

Reaction forces (W_F and W_R)

$\sum F_y = 0 = -3.5 - 8 + W_F + W_R = 0$
$W_F + W_R = 3.5kN + 8kN = 11.5kN$

$\sum M_F = 0 = 3.5*0.825 - 8*0.9 + 1.58* W_R = 0$
$1.58\ W_R = 4.3125$
$W_R = 2.73kN$
$W_F = 11.5 - 2.73 = 8.7kN$

Question 3



The beam shown opposite is cantilevered from a rigid wall. A force F is applied at the free end of the beam.

The beam is a standard RSJ which is designated UB 203x102x23. A British Standard (BS4) is attached that gives relevant physical properties for beams, for example the 2nd moment of area (*I*) (moment of inertia).

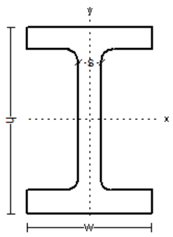
The table below contains data acquired from tests to determine the radius of curvature of the beam under increasing bending loads.

Using the Engineers Bending Equation, $\frac{M}{I} = \frac{E}{R} = \frac{\sigma}{y}$

and a bending moment of 115kNm, find Young's Modulus ® for the beam and determine the material of the beam.

(*M*) Bending Moment (kNm)	30	40	50	60	80	100	120	150	170	200
® Radius of Curvature (m)	145	110	85	75	55	42	31	32	24	25

British Standard 4



Properties of some British Column and Beams according BS 4.

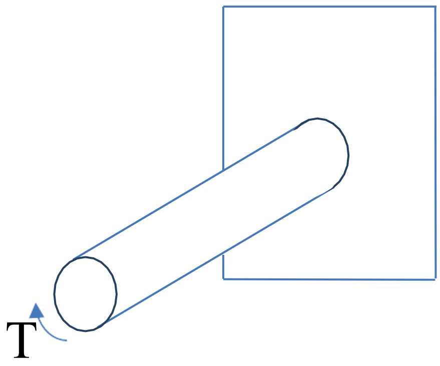
Designation	Dimensions					Static Parameters			
						Moment of Inertia		Section Modulus	
	Depth h *(mm)*	Width w *(mm)*	Web Thickness s *(mm)*	Sectional Area *(cm²)*	Weight *(kg/m)*	I_x *(cm⁴)*	I_y *(cm⁴)*	W_x *(cm³)*	W_y *(cm³)*
UB 127 x 76 x 13	127	76	4	16.5	13	473	55.7	74.5	14.7
UB 152 x 89 x 16	152.4	88.7	4.5	20.3	16	834	89.6	109.5	20.2
UB 178 x 102 x 19	177.8	101.2	4.8	24.3	19	1356	137	152.5	27
UB 203 x 102 x 23	203.2	101.8	5.4	29.4	23.1	2105	163.9	207.2	32.2
UB 203 x 133 x 25	203.2	133.2	5.7	32	25.1	2340	307.6	230.3	46.2
UB 203 x 133 x 30	206.8	133.9	6.4	38.2	30	2896	384.7	280	57.5
UB 254 x 102 x 22	254	101.6	5.7	28	22	2841	119.3	223.7	23.5
UB 254 x 102 x 25	257.2	101.9	6	32	25.2	3415	148.7	265.5	29.2
UB 254 x 102 x 28	260.4	102.2	6.3	36.1	28.3	4005	178.5	307.6	34.9
UB 254 x 146 x 31	251.4	146.1	6	39.7	31.1	4413	447.5	351.1	61.3
UB 254 x 146 x 37	256	146.4	6.3	47.2	37	5537	570.6	432.6	78
UB 254 x 146 x 43	259.6	147.3	7.2	54.8	43	6544	677.4	504.1	92

The circular bar shown opposite is fixed to a rigid wall. A torque, *T* is applied to the free end of the bar.

The bar is 3.37m long with a constant diameter of 36mm. Using the formula for polar second moments: $J = \frac{\pi d^4}{32}$ show that $J = 1.649 \times 10^{-7} m^4$.

The table below contains data acquired from tests to determine the angle of twist (θ) in radians of the bar under increasing torque.

Using the Torsion Equation $\frac{G\theta}{L} = \frac{T}{J} = \frac{\tau}{r}$ and a torque of 450 Nm, find the modulus of rigidity (*G*) for the beam and the material of the bar.



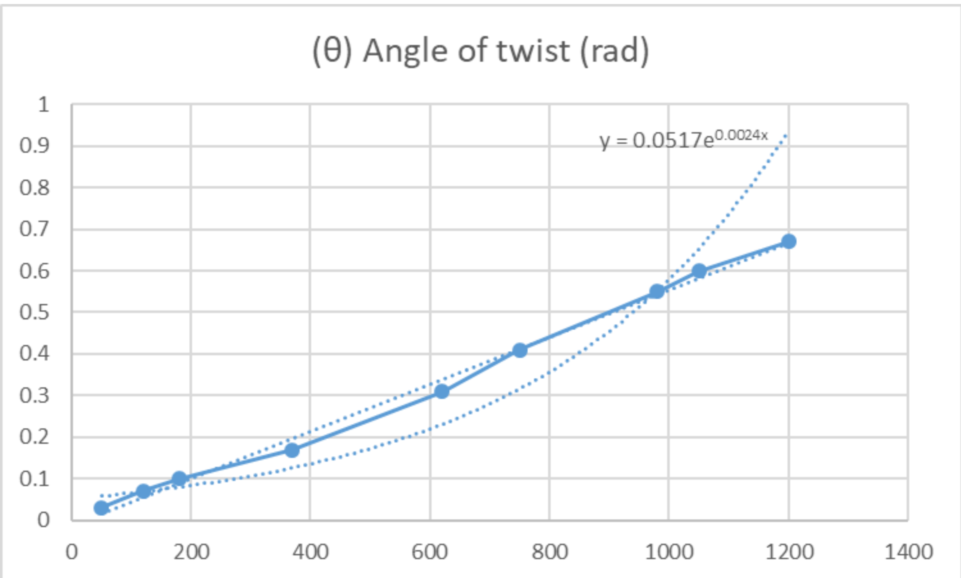
(*T*) Torsion (Nm)	50	120	180	370	620	750	980	1050	1200
(θ) Angle of twist (rad)	0.03	0.07	0.10	0.17	0.31	0.41	0.55	0.60	0.67

ANSWER

<u>Question 3:</u>

a) From the table I = 2105 cm^4

M = 115kNm



R = 34 m (interpolated from table)

b) Material of the beam

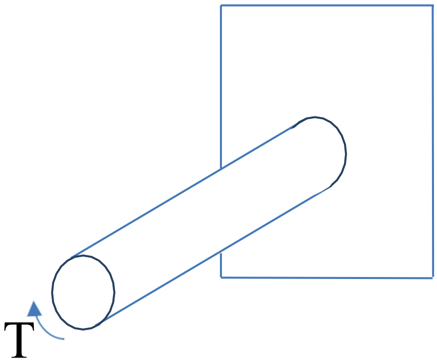
$$\frac{M}{I} = \frac{E}{R} = \frac{\sigma}{y}$$

$E = \frac{MR}{I} = \frac{115*10^{3}\,Nm*34m}{2105*10^{-8}\ m^{4}} = 185.75\ Gpa$, the material is Steel

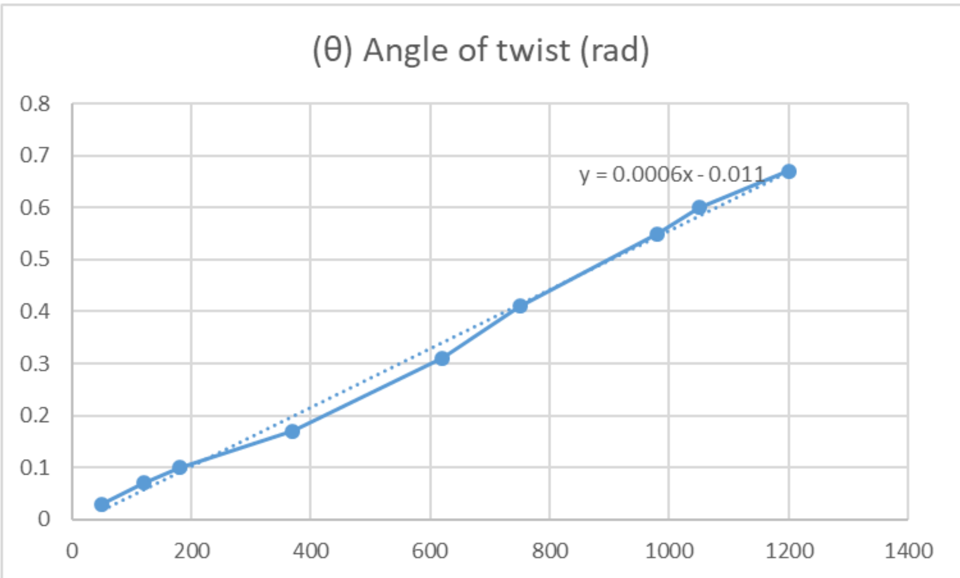
Given:

L= 3.37m
Φ = 36mm
J = $1.649*10^{-7}m^{4}$
T = 450 Nm

Required: G =?



$$\frac{G\theta}{L} = \frac{T}{J}$$



θ = 0.22 rad

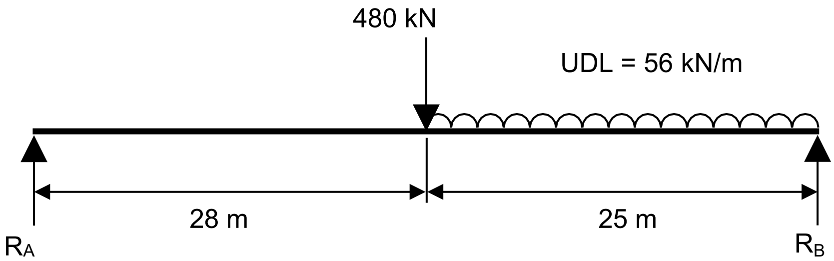
$G = \frac{LT}{\theta J} = \frac{3.37m*450Nm}{0.22\ rad*1.649*10^{-7}\ m^{4}} = 41.802\ Gpa$, the material is Brass

Question 4

The diagram below represents the instantaneous loading configuration of the support columns caused by a moving freight train on a bridge.

Calculate the support reactions and produce both the shear force and bending moment diagram for this load configuration.

Clearly indicate the magnitude and position of the maximum bending moment and any points of contraflexure that may be present.



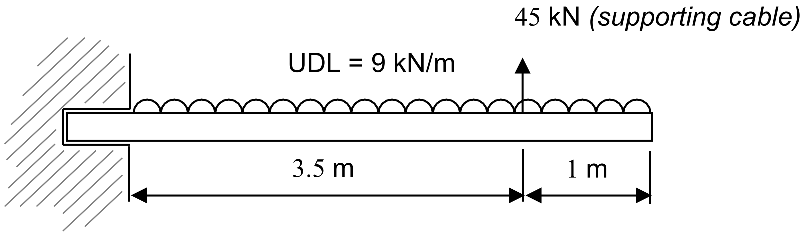
Explain the meaning of static equilibrium when working with simple force systems, both concurrent and non-concurrent loading systems. Describe how simply supported beams can be approximated to deal with more complex loading systems, including an explanation of Uniformly Distributed Loads (UDL's).

The diagram below shows a cantilever beam loaded as shown and suspended at one end by a supporting cable.

Calculate the support reactions and produce both the shear force and bending moment diagram for this load configuration.

Clearly indicate the magnitude and position of the maximum shear force and the maximum bending moment and any points of contraflexure that may be present.

Cantilever beam

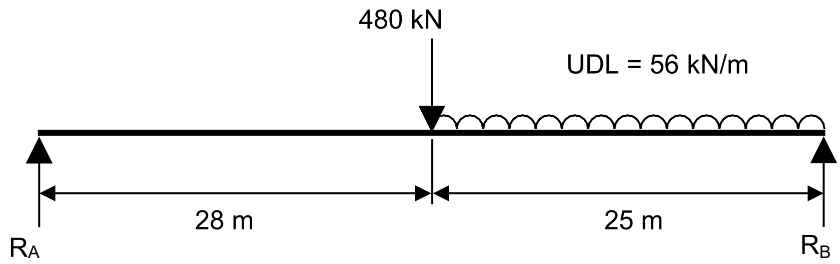


Explain the significance of producing both the shear force and bending moment diagrams and the information/data gained from them. Explain the significance of points of contraflexure.

ANSWER

Question 4

Given:



Required:

a) R_A and R_B
b) SFD, BMD
c) Location of maximum moment and point of contra flexure

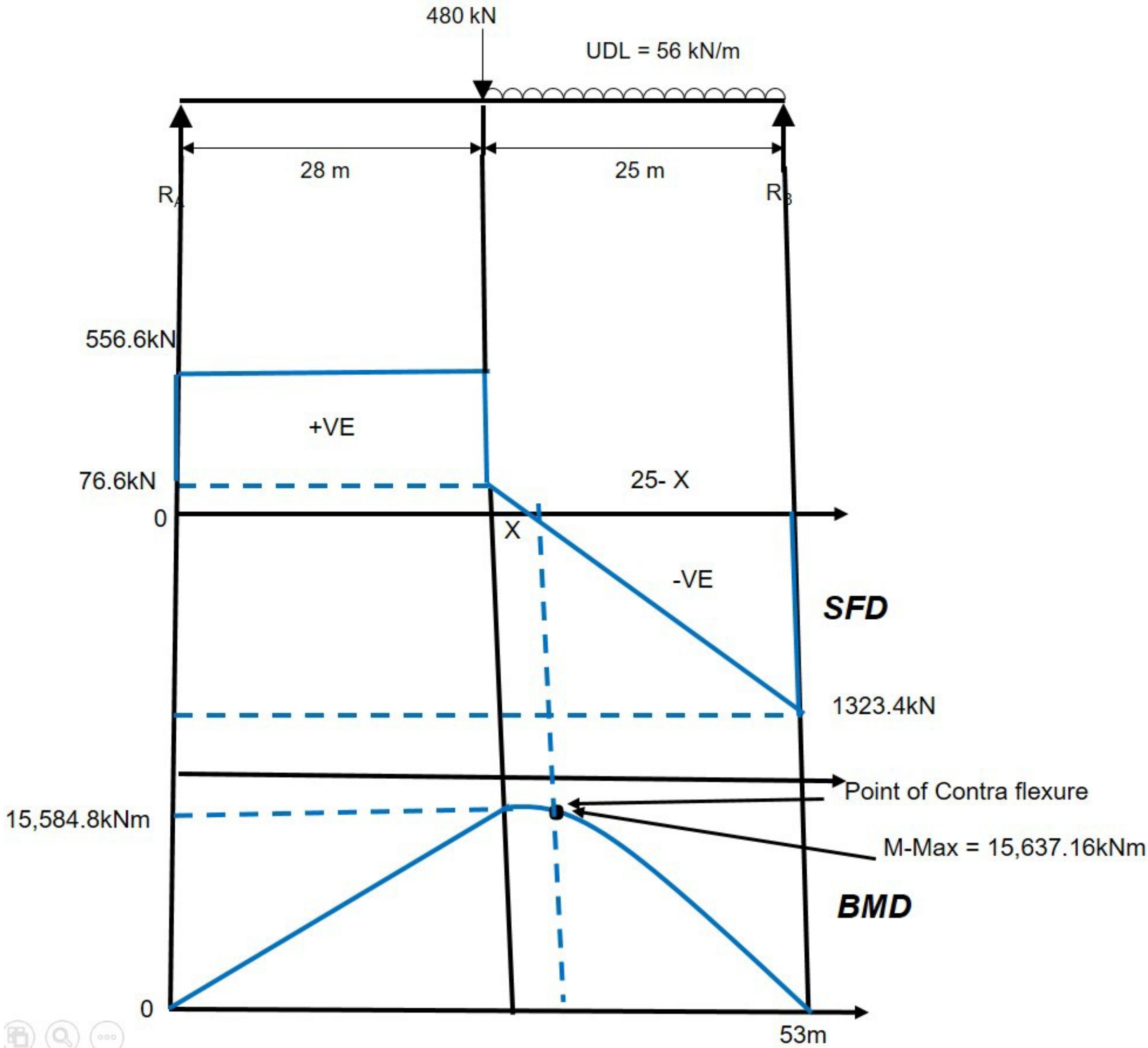
Solutions:

$\sum F_y = 0$
The sum of downward forces must be equal to the sum of upward forces
$\sum F_y = 0 = RA + R_B - 480 - 25*56 = 0$
$R_A + R_B = 1880kN$

$\sum M_X = 0$
$28 * 480 + 40.5 * 25 * 56 = 53R_B$
$13440 + 56700 = 53R_B$
$R_B = 1323.4kN$
$R_A + R_B = 1880kN$
$R_A = 1880 - 1323.4 = 556.6kN$

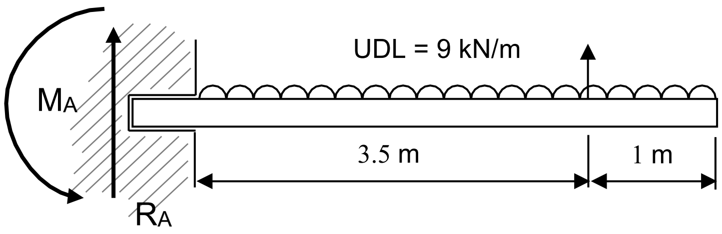
***Static equilibrium:* –** a state in which all acting forces on a body are in equilibrium in which the resultant forces are balanced by support reactions. That is $\sum F_y = 0$ and $\sum M_X = 0$.

Approximation of simply supported beams: – supports and loadings should be modelled and presented on the simply supported beam. That is, presenting the system as a free body diagram to better analyse the system equilibrium.



$$\frac{76.6}{x} = \frac{1323.4}{25-x} \Rightarrow 1915 - 76.6x = 1323.4 \Rightarrow x = 1.367$$

Maximum moment = 29.367 m



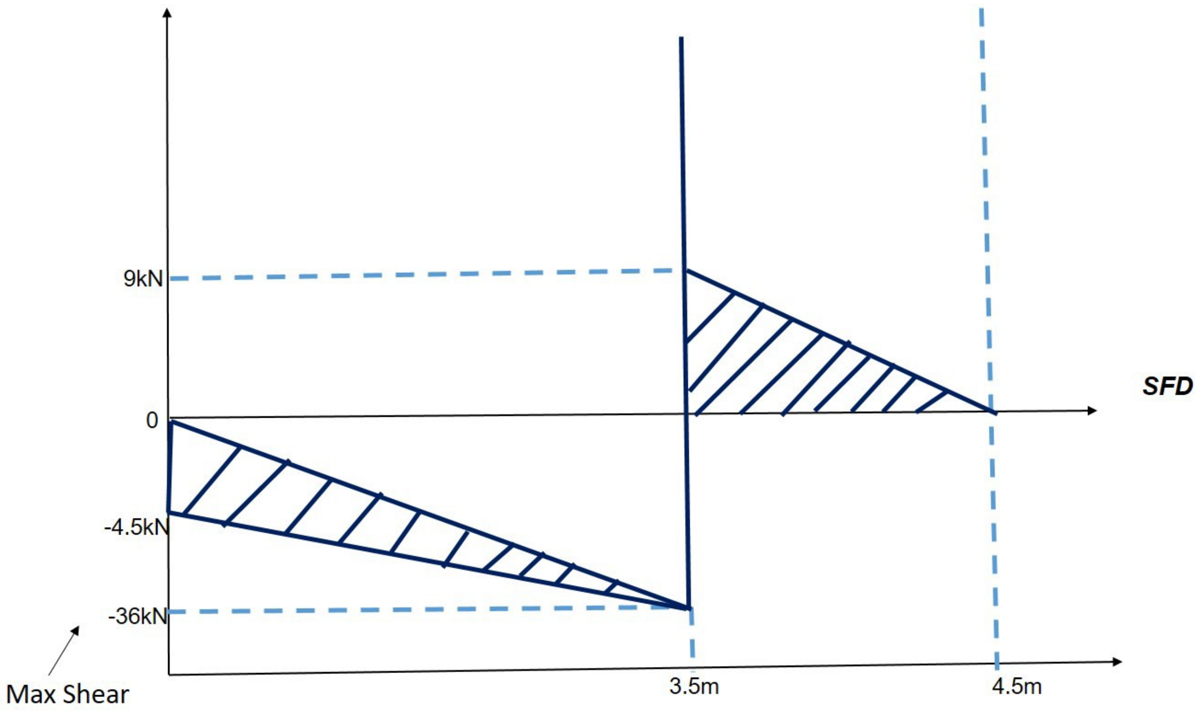
Required:

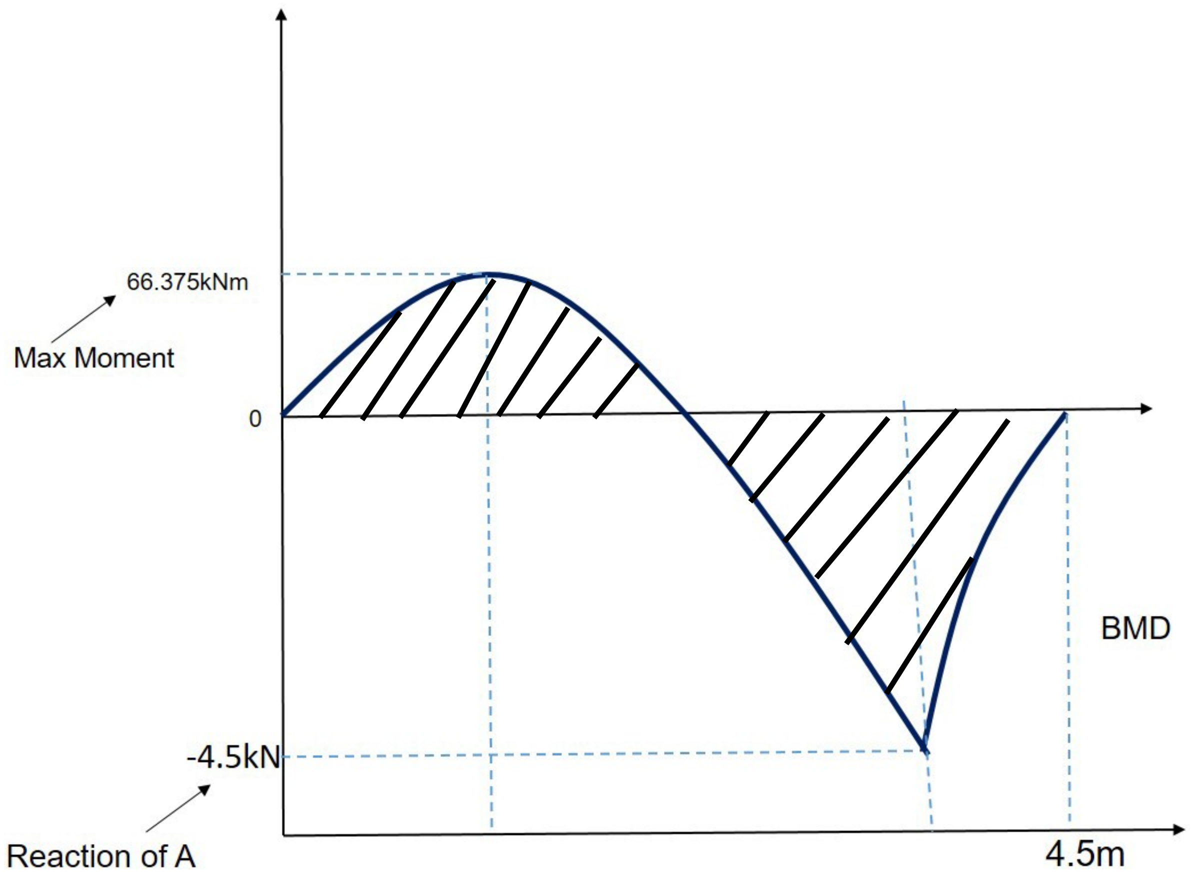
a) Reaction forces
b) SFD, BMD
c) Position of maximum moment and shear
d) Point of contra flexure

Solutions:

R_A = 4.5*9 – 45= -4.5Kn

$M_A = 9 * 4.5 * \frac{4.5}{2} - 45 * 3.5 = -66.375$





The significance of shear force and bending moment diagram is in the design and material selection of beams. As we have seen in Question 2 on I-beam.

Question 5

A structural member commonly loaded in shear, but seldom in tension, is the rivet. Figure A below shows a riveted connection, in which two plates overlap to form a lap-joint.

Now consider what happens to the rivet when the joint is subjected to a load. Two equal and opposite forces F applied to the plates as shown tend to move the top half of the rivet relative to the bottom half.

A section of the rivet tends to slide across the interface X-X of the two plates. It is usual to assume that the load is taken equally by all the rivets within the joint.

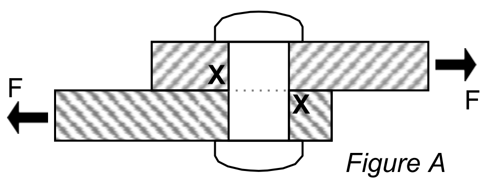
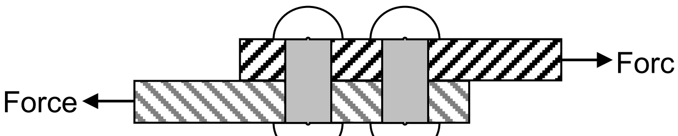
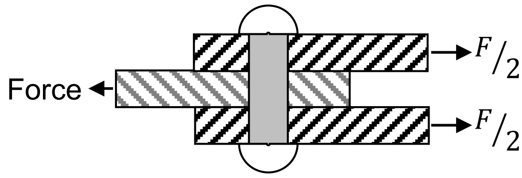


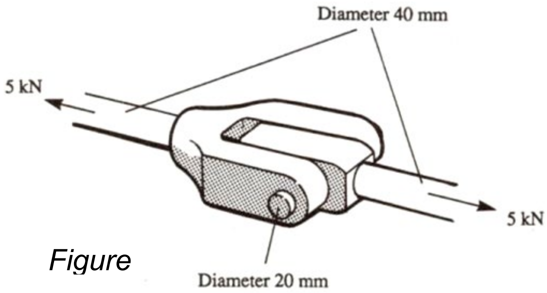
Figure A



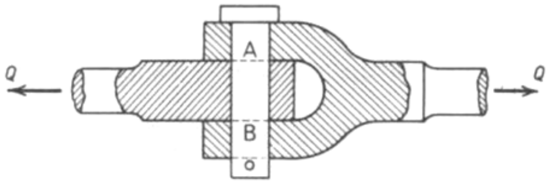
Figure



Figure



Figure



Figure

Discuss and compare the advantages and limitations of single shear (Figure A) and double shear riveted joints (Figures B, C, D and E). Within your discussion compare and contrast joints using single and double shear arrangements in addition to using typical worked numerical examples to validate key areas of your discussion.

Answer

<u>Question 5</u>

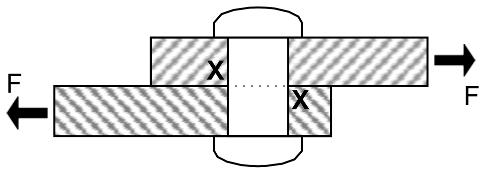
Given: rivet connections A, B, C and D.

Required:

Single shear sections carries half of the load that double shear sections carry. For the same area of shear (A) we can show as:

For rivet A

$$\tau = \frac{F}{A} \Rightarrow F = \tau A$$



For rive B, C, and D

$$\tau = \frac{F}{2A} \Rightarrow F = 2\tau A \text{ ,double benefit}$$

Single shear carries all load on one face while double shear carries it on two faces, so the shear stress is lower by a factor of 2 for a given load.

REFERENCE

- Canvas resources
- Cloud Engineering Software