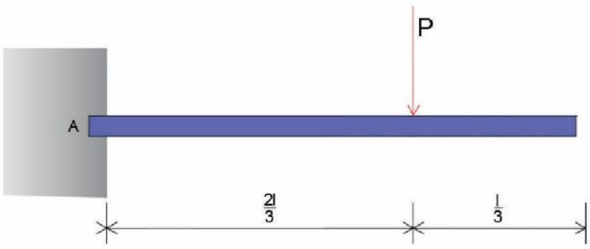
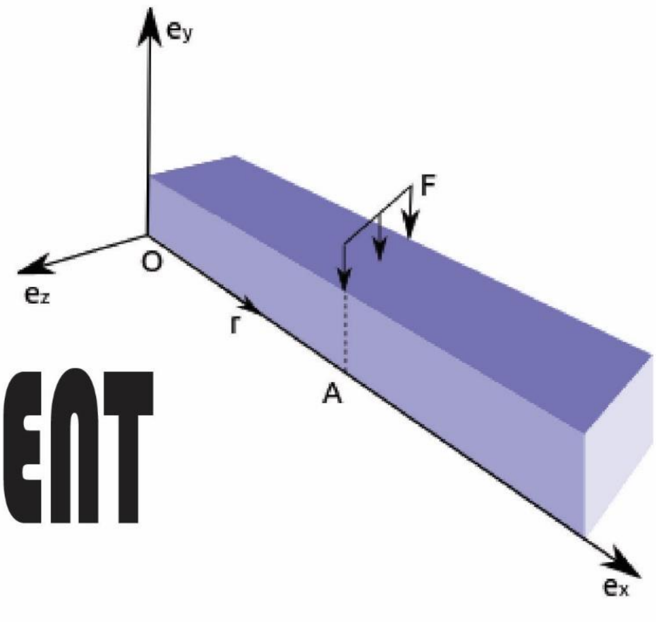
MUHAMAD FAIZ BIN JOFRI
MD SAIFUDDIN BIN MD YUSOP
MUHADIR BIN SAEMAN



SHEAR FORCE AND BENDING MOMENT



DECLARATION OF COPYRIGHT

Edisi Pertama

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Muhammad Faiz Jofri, 1978-
SHEAR FORCE AND BENDING MOMENT / MUHAMMAD FAIZ BIN JOFRI,
MD SAIFUDDIN BIN MD YUSOP, MUHADIR BIN SAEMAN.
Mode of access: Internet
eISBN 978-967-0838-81-6
1. Strength of materials.
2. Girders.
3. Government publications--Malaysia.
4. Electronic books.
I. Md. Saifuddin Md. Yusop, 1986-. II. Muhadir Saeman, 1977-.
III. Title.
620.112

Diterbitkan oleh:
Politeknik Melaka
No 2, Jalan PPM 10
Plaza Pandan Malim
75250 Melaka

Tel : +06-337 6000
Faks : +06-337 6007
Website : http://polimelaka.mypolycc.edu.my

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful. Peace and blessings of Allah be upon His Messenger, Muhammad, and all his family and companions. Alhamdulillah, all praises to Allah for the blessing and guidance in completing this book.

We want to thank all of the people who helped, discussed ideas, read, wrote, gave comments, allowed us to use their words as quotes, and helped us with the editing and proofreading. Finally, we would like to take this time to thanks our family, friends, and students for all of their support during the process and for their ideas, knowledge, and comments. Special thanks also to Polytechnic Melaka to make our e-book successfully publish.

ABSTRACT

The Strength of Materials course is a requirement for those pursuing Diploma in Mechanical Engineering at Polytechnic Malaysia. Characterizing the qualities of those solids under the load is the aim of the study of solid materials under a load, often known as "strength of materials." Shear and bending moment diagrams are analytical tools that are used with structural analysis to calculate the shear force and bending moment at a particular location of a structural element, like a beam, to help with structural design.

TABLE OF CONTENTS

1.0 INTRODUCTION

Two parallel forces acting in opposition to one another cause shear forces. For instance, the expansion and contraction of the sheet metal plate sections used to construct a huge boiler results in an equal and opposite force being applied to the rivets. Rotational forces within the beam called "bending moments" cause the beam to bend. Every external force multiplied by the distance perpendicular to the direction of the force adds up to the total bending moment at any point within a beam.

Take a look at the beam in the picture that is being loaded transversely. The deflections happen in the same plane as the loading plane, which is known as the bending plane. This chapter discusses the shear forces and bending moments that the loads cause in beams.

1.1 Shear force and bending moment of beams

The shearing force is defined at any segment of a beam carrying transverse loads as the algebraic sum of the forces taken on either side of the section. The bending moment at any section is calculated as the algebraic sum of the moments of the forces about the section, again taken on either side.

1.1.1 Beams

A structural element that rests on supports and carries vertical loads is called a beam. Beams are typically placed horizontally; the quantity and size of the external load that a beam can support relies on:

a. The separation between supports and the lengths that protrude from them;

b. The kind and magnitude of the load;

c. The supporters' kind; and

d. The beam's cross-section and elasticity.

Cantilever beam- this type of beam is free at one end and fixed at the other end.

Simply supported beam- this type of beam is supported at both the ends.

Fixed beam- here both the ends of the beam are fixed.

Continuous beam- this type of beam is supported on more than two supports.

Overhanging beams- this type of beam has an extended part beyond its support.

1.2 Classification of beams

There are various kinds of beams used in engineering: A beam that is simply supported has ends that are supported but have no moment resistance and are free to spin. A beam that is fixed or encastré (encastrated) is one that is held at both ends and prevented from rotating. A straightforward beam that hangs over its support at one end.

1.2.1 Cantilever Beam

A built-in or encastre's support is regularly encountered. The outcome fixes the direction of the beam at the support. The support must apply a "fixing" moment M and a response R to the beam in order to do this. Cantilever is the name for a beam with this type of fixed end. The reactions are not statically determinate if both ends are fixed in this manner. In reality, it is frequently impossible to achieve perfect fixing, and the applied fixing moment will be correlated with the angular movement of the support. When in dispute about the stiffness, it is better to presume that the beam is supported freely.

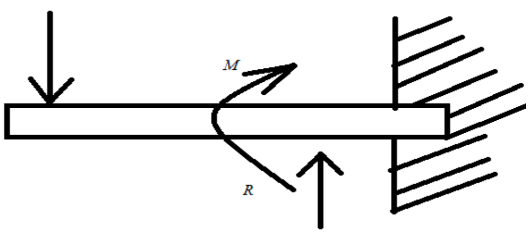


Fig. 1.0 Cantilever beam

1.2.2 Simply Supported Beam

A beam that rests on two supports and can move horizontally is said to be simply supported. Bridges, building beams, and machine tool beds are examples of common practical applications for simply supported beams with point loadings.

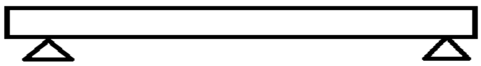


Fig. 2.0 Simply supported beam

1.2.3 Overhanging Beam

A beam that is freely supported at two points and has one or both ends that extend beyond these supports is referred to as an overhanging beam. Most of the time, one support in an overhanging beam is a hinge support, while the other is a roller support with one end that is free like a cantilever.

Fig. 3.0 (i) Overhanging at one end (ii) Overhanging at both ends

1.2.4 Propped Cantilever Beam

A cantilever beam is referred to as being propped if a support is placed at an appropriate spot to prevent the beam from deflecting.

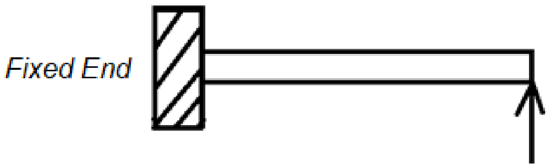


Fig. 4.0 Propped Cantilever beam

1.2.5 Fixed Beam

A fixed beam is where two ends are firmly fastened to or integrated into the supporting walls or columns.

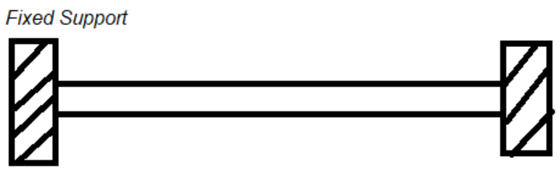


Fig. 5.0 Fixed beam

1.3 Types Of Loading

There are four different loading types that are taken into consideration: concentrated load, uniformly distributed load (UDL), triangular load, and hat type load.

1.3.1 Point Load or Concentrated Load

These loads are typically thought of as acting at a point. Practically speaking, a beam cannot support a point load. When a member is positioned on a beam, it fills in a certain breadth or space. But for calculations, we treat the load as transmitting at the member's centre axis.

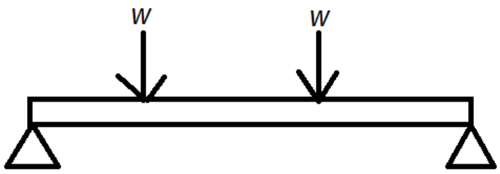


Fig. 13. Concentrated load

1.3.2 Uniformly Distributed Load or U.D.L

A load that is distributed uniformly over a beam and measured in Newton-meter. It means that each unit of length is loaded with the same amount of weight.

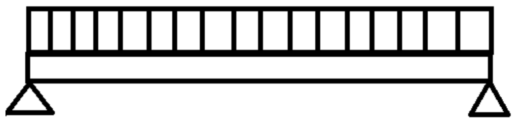


Fig. 14. UDL

1.3.3 Gradually Varying Load

It is referred to as a uniformly varying load if the load is distributed and varies consistently over the length of a beam.

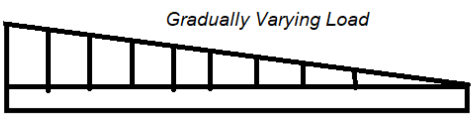


Fig. 15 Gradually varying load

1.3.4 Continuous Beam

Continuous beams are those that rest on more than two supports. This could have one or both ends that are overhanging.

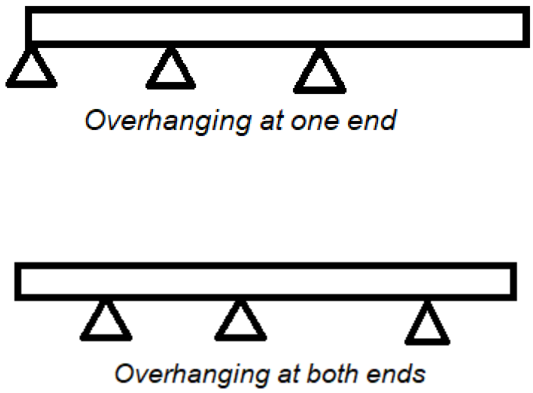


Fig. 16. Overhanging beam

1.3.5 Span

Clear Span: This is the space between two supports that is clearly visible on the ground.

Effective Span: This refers to the horizontal distance between the support's centre of the end bearings. Clear span plus oceanic bearing equals effective span.

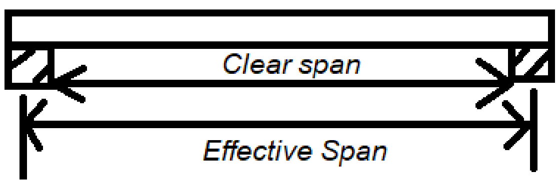


Fig. 17. Effective and clear span

1.4 Shear force

The shearing force is defined as the algebraic sum of the forces applied on either side of any section of a beam carrying transverse loads. The bending moment at any section is calculated by adding the moments of the forces acting on that section, again taken from each side. A practical sign convention must be chosen so that the shearing-force and bending-moment values calculated on either side of the section have the same magnitude and sign. Shearing-force and bending-moment diagrams illustrate how these values change across a beam's length under any given fixed loading scenario.

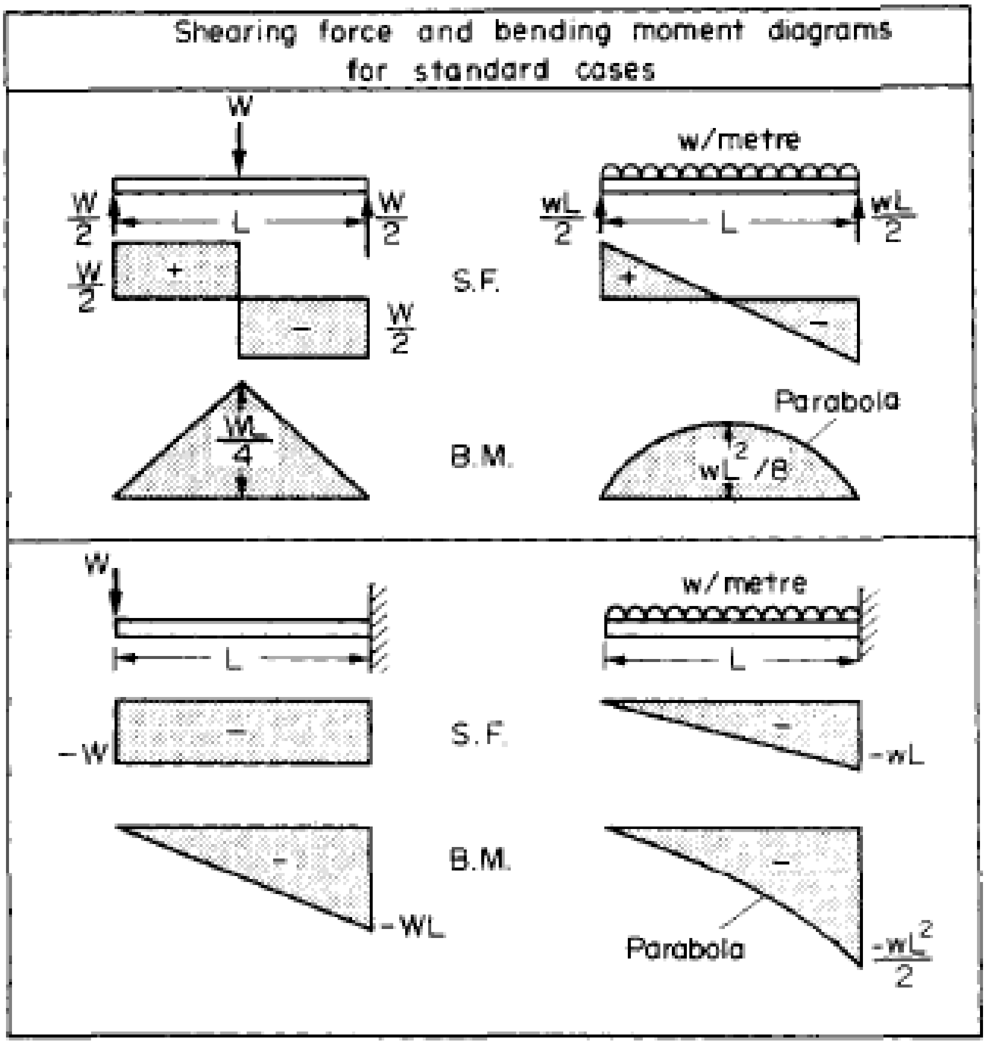


Fig. 18 Shear force and bending moment diagram

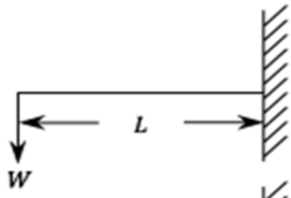
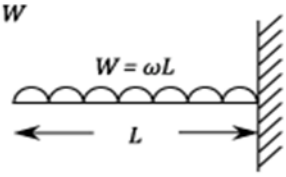
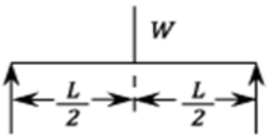
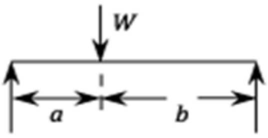
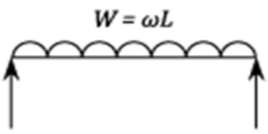
LOADING	$\hat{F}$	$\hat{M}$
	W	WL (Fixed End)
	W (Fixed End)	$\frac{WL}{2}$ (Fixed End)
	$\frac{W}{2}$	$\frac{WL}{4}$ (Centre)
	$\frac{Wb}{L}$	$\frac{Wab}{L}$ (Load)
	$\frac{W}{2}$ (Support)	$\frac{WL}{8}$ (Centre)

Fig. 19 Loading in beams, shear force and bending moment

There will be resultant forces at every section of a beam carrying transverse loads that, for equilibrium, must be equal and opposite, and which combined action tends to shear the section in one of the two ways. The algebraic total of the forces applied to one side of the section is consequently used to define the shearing force (S.F.) at the section. Which side is chosen is solely a question of convenience, but a convenient sign convention must be used in order for the value received on both sides to have the same magnitude and sign.

1.4.1 Convention for shearing force (S.F.) signs

Positive forces are those that are directed either upwards or downwards away from a portion. In light of this, Figure —a depicts a positive S.F. system at X-X while Figure —-b depicts a negative S.F. system. In addition to the shear, every portion of the beam will experience bending or a resultant bending moment (B.M.), which is the sum of the moments of all the separate loads. To reiterate, equilibrium requires that the values on either side of the section be equal. Thus, the bending moment (B.M.) is defined as the algebraic sum of the moments of the forces acting on the section, measured from either side of the section. For S.F., it is necessary to choose a practical sign convention.

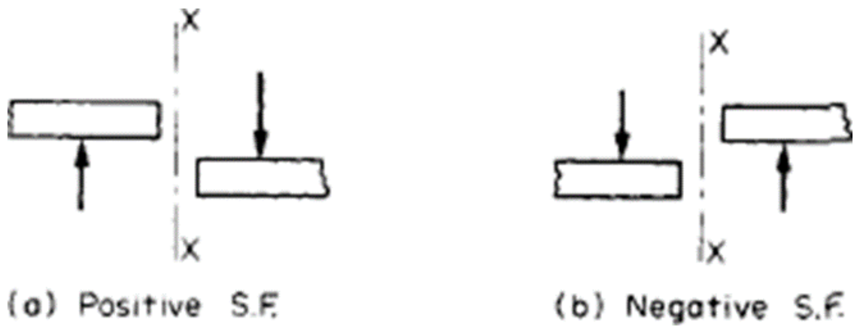


Fig. 20 shear force sign convection

1.4.2 Bending moment (B.M.) sign convention

Moments that are counter clockwise to the right and clockwise to the left are advantageous. As a result, Fig. a depicts a positive bending moment system that causes the beam at X-X to sag, while Fig. b displays a negative B.M. system that causes the beam to hobble.

Although the aforementioned sign conventions for S.F. and B.M. are somewhat arbitrary and could be completely reversed, it should be noted that the systems selected here are the only ones that produce the mathematically accurate signs for slopes and beam deflections in subsequent work and are therefore strongly advised.

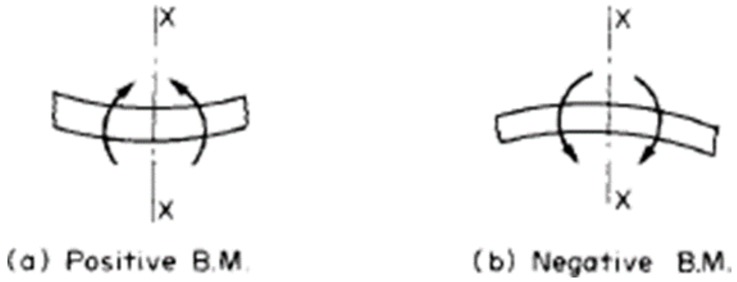


Fig. 21 Bending moment sign conventions

1.4.3 Shearing force

The tendency for the portion of the beam on one side of the section to slide or shear laterally in relation to the opposite portion is represented by the shearing force (SF) at any section of a beam. A beam carrying weights W1, W2, and W3 is seen in the diagram. It is only supported at the two locations where reactions R1 and R2 occur. Assume that section XX divides the beam into two pieces.

Since the entire beam is in equilibrium, the resulting force to the right of AA must be F below. The outcome of the loads and reaction operating on the left of AA is F vertically upwards. At section AA, F is referred to as the Shearing Force. The algebraic sum of the lateral components of the forces operating on either side of the section determines the shearing force at any segment of a beam. Only the lateral components are employed to determine the shear force in cases when forces are neither axially directed nor laterally directed.

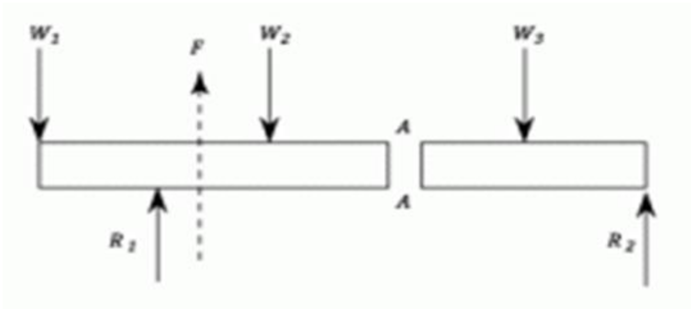


Fig 22 shear force through a section

1.4.4 Bending Moment

In a similar way, it can be observed that if the bending moments (BM) of the forces to AA's left are clockwise, then the bending moment of the forces to AA's right must be anticlockwise.

The algebraic sum of all moments about the section of all forces operating on each side of the section is known as the "bending moment at AA." Bending moments are regarded as positive when the moment on the left section is clockwise and on the right anticlockwise. As the beam tends to become concave upwards at AA, this is known as a sagging bending moment. Hogging is the technical word for a negative bending moment.

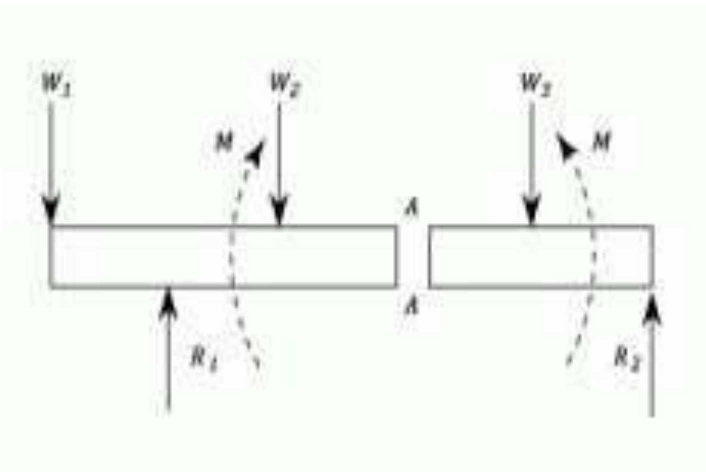
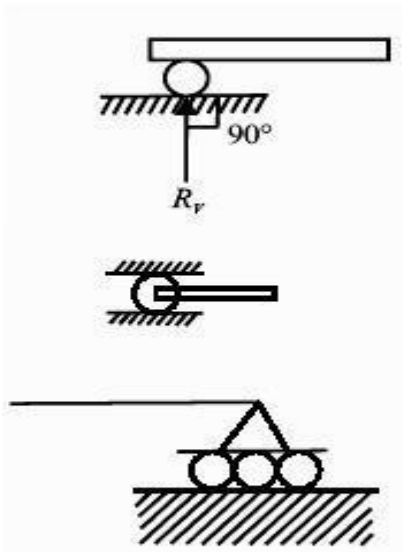


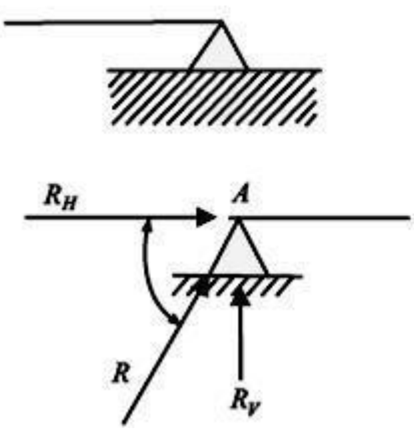
Fig. 23 bending moment through a section

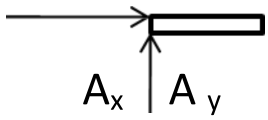
1.5 Types Of Support & Reaction

Beam ends are supported on rollers in a roller support system. The response is acute. You can consider a roller to be frictionless. One vertical response just at the roller support

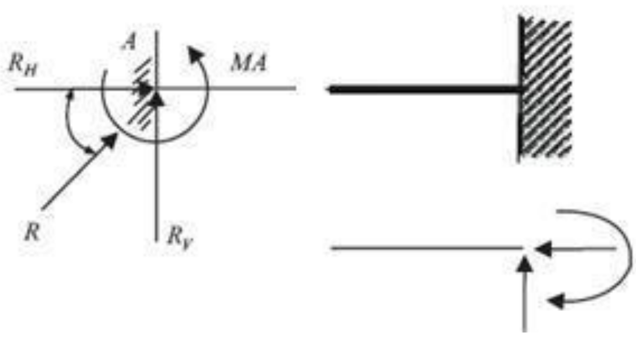


A beam cannot move in any direction at a hinged end due to the hinged (pin) support. Support won't create any moments of resistance, but it can create reactions in any direction.





Fixed support—At such support, the end of the beam is not free to translate or rotate, and there are THREE reactions at the fixed end: a moment, a vertical reaction, and two horizontal reactions (M).



Moment= F x d

1.5.1 Equation of Static Equilibrium

For x-axis: Sum of right forces = sum of left forces

For y-axis: Sum of up forces = sum of down forces

For moment: Sum of up forces = sum of down forces

Sum of moment clockwise = Sum of moment counter clockwise

1.5.2 Steps to Consider

- ✓ Find the reaction force
- ✓ Draw shear force diagram (SFD)
- ✓ Draw bending moment diagram (BMD)
- ✓ Define the value of moment maximum from the BMD
- ✓ Define the contra flexure point from BMD

1.5.3 Shear force

Tips for Sketch SFD

Force calculation start from left to right for simply supported beam and overhanging beam

Force upward is positive, downward is negative.

1.5.4 Bending Moment

Tips to Sketch BMD

Calculation for the overhanging beam and the simply supported beam begins on the left. Cantilever beam calculations that begin at the free end.

Important Points Must Be Kept In Mind While Drawing The Shear Force And Bending Moment Diagram

The following points must be kept in mind while drawing the shear force and bending moment diagrams.

1. To begin with, focus on either the left or right side of the area.

2. Add the forces, including reactions, normal to the beam on one of the sides; if the right-hand side of the section is chosen, the downward force is regarded as +ve and the upward force as -ve.

3. Shear force and bending moment readings are shown with the positive values above the baseline and the negative ones below.

4. When there is a vertical point load, the shear force diagram will abruptly reduce or increase, as illustrated by a vertical straight line at a section.

5. Because any two vertical loads will have an equal shear force, the shear force diagram between them will be horizontal.

6. The bending moment at the two supports of a simply supported beam and also the free end of a cantilever will be zero.

1.5.5 Contraflexure Point

Point of Contra flexure. It is the point in the BMD where the BM changes slope from an increasing one to a decreasing one. Contra means opposite and flexure means bending. Some authors consider point of inflexion and point of contra flexure to be synonymous.

A point in a bending beam is referred to be a point of contraflexure if there is no bending there. It is the location where the zero line and the bending moment curve cross in a bending moment diagram. Or, to put it another way, where the bending moment shifts from a negative to a positive sign, or vice versa.

When developing reinforced concrete or structural steel beams or when planning bridges, knowledge of the contraflexure's location is extremely helpful.

There may be less need for flexural reinforcement at this time. However, it is not advised to completely forgo reinforcement at the site of contraflexure because it is doubtful that the precise position can be accurately pinpointed. Additionally, sufficient reinforcement must extend past the point of contraflexure in order to strengthen the connection and enable the transmission of shear forces.

2.0 RELATIONSHIP BETWEEN LOAD (w), SHEAR FORCE (F), AND BENDING MOMENT (M).

The length of a thin slice of a loaded beam at a distance of x from the origin O is shown in the picture below.

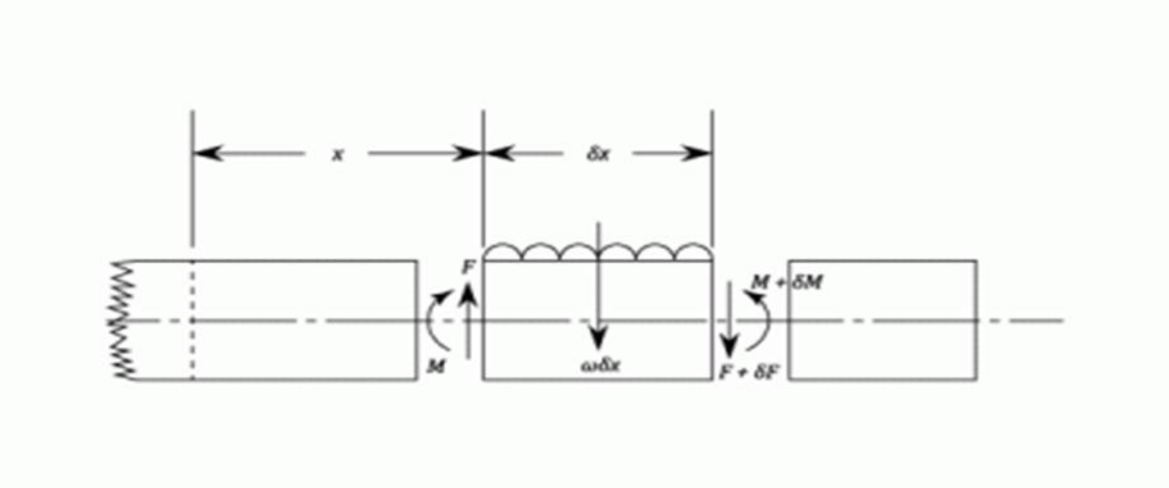


Fig. 24: Loaded beam of origin O, length x

Let F be the shearing force at section x. In the same manner, the bending moment is M at x. The total load is, operating roughly (exactly if uniformly distributed) through the centre C if w is the mean rate of loading of the length. Under the influence of these forces and couplings, the element must be in equilibrium to provide the subsequent equations:

Taking a Moment to Consider C:

$$M + F.\frac{\delta x}{2} + (F + \delta F)\,\frac{\delta x}{2} = M + \delta M \quad (1)$$

Ignoring the product inside the limit:

$$\delta F.\delta x$$

$$F = \frac{dM}{dx} \quad (2)$$

Vertically resolved:

$$w\delta x + F + \delta F = F \tag{3}$$

$$Or \qquad w = -\frac{dF}{dx} \tag{4}$$

$$= -\frac{d^2M}{dx^2} \qquad from\ equation\ (2) \tag{5}$$

Equation (2) shows that there will be no shearing force if M varies continuously. Corresponding to the highest or lowest bending moment. As observed in the instances, "peaks" in the bending moment diagram typically appear at concentrated loads or responses $F = \frac{dM}{dx} = 0$; however, these are not represented by, even if they could really represent the largest bending moment on the beam. In order to determine the maximum bending moment, it is thus not always necessary to look into the points of zero shearing force.

A point of inflection or contraflexure is the location on the beam where the kind of bending shifts from sagging to hogging and where the bending force must be zero.
Equation (2) between x = a and x = b is integrated to yield:

$$M_b - M_a = \int_a^b F\,dx \tag{6}$$

This demonstrates that the area beneath the shearing force diagram is the increase in bending moment between two parts.
similar equation for integration (4)

$$F_a - F_b = \int_a^b w\,dx \tag{7}$$

has the same area as the load distribution diagram's bottom. Equation (5) is integrated to produce:

$$M_a - M_b = \int \int_a^b w \, dx.dx \quad (8)$$

When the rate of loading cannot be represented in an algebraic manner, these relations can be quite helpful since they offer a pictorial solution.

2.1 Shear Force Diagram (SFD)

The shear force fluctuation along the length of the beam is depicted in a figure called a shear force diagram. Finding the shear force and bending moment values at the chosen spot on the beam in the problem's example will yield a shear force diagram and bending moment diagram.

When a perpendicular force is applied to static material, shearing force results (in this case a beam). You can try cutting a piece of bread with a knife in our actual situation and in close proximity to us, students. Imagine cutting the bread with a knife. Consider that the knife is the point load and the bread is the beam. The bread is cut by the knife's downward force, which shears the bread's surface. These forces act on a beam at different places. The cutting point is crucial to identifying where these shears are located at their strongest spots since the beam may fail.

2.2 Maximum Bending Moments

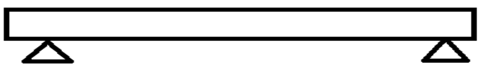
In cases where a beam loaded with point loads, and the position of maximum bending moment can be found in the inspection bending moment diagram. For the combined load and the position of maximum bending moment obtained from bending moment diagram. Thus the fact that the maximum or minimum value of a given function when $\frac{dy}{dx}$ = 0 is used. For the bending moment equation $\frac{dM}{dx}$ = 0 is used to determine the position of the maximum value.

3.0 EXERCISE AND SOLUTION

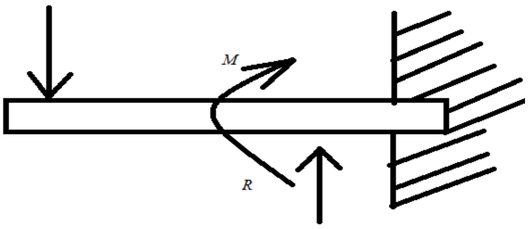
EXERCISE

1. List TWO (2) types of beams with illustrations.

SOLUTION



Simply supported beam



Cantilever beam

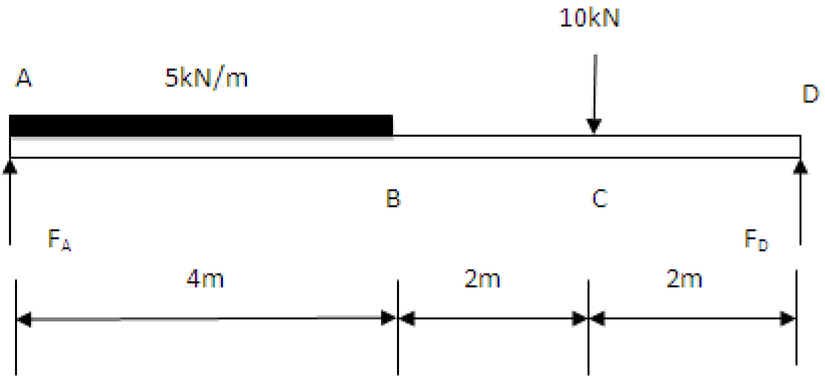
EXERCISE

2. A beam ABCD with the length of 8 m has been supported by simple support beam on A and D. Part AB has been subjected to distributed load 5 kN/m while part C has been subjected to point load 10 kN. The distance between point A and point B is 4 m, point B and point C is 2 m while point C and point D is 2 m. Define

    i) Sketch the figure of the beam
    ii) Reaction force for part A and D
    iii) Sketch the diagram of shear force
    iv) Draw diagram of bending moment
    v) Location and value of point of maximum value

SOLUTION

Free Body Diagram:



$\Sigma F = 0$

$F_A + F_D - 5(4) - 10 = 0$

$F_A + F_D = 20 + 10$

$F_A + F_D = 30$ kN ---------------------------------------(1)

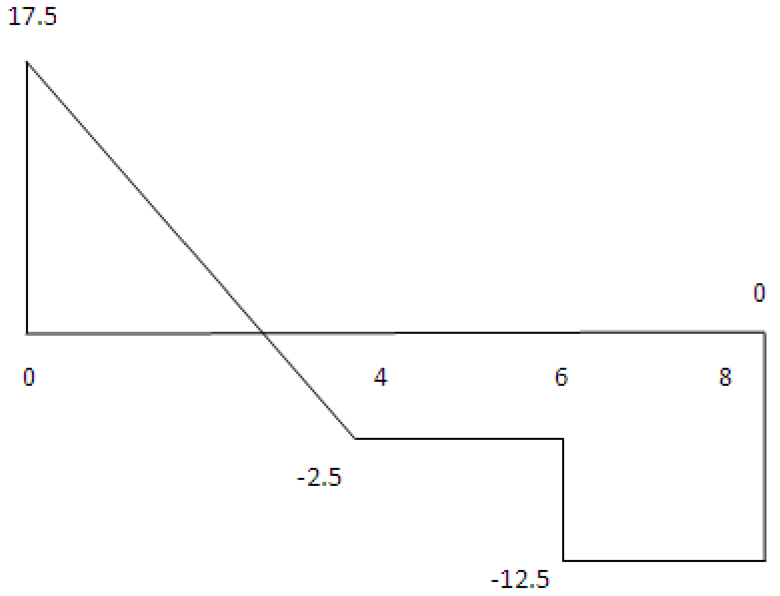
$+ \circlearrowright M_A = 0$

$5(4)(\frac{4}{2}) + 10(6) - F_D(8) = 0$

$8F_D = 100$

$F_D = (\frac{100}{8})$

$F_D = 12.5$ kN ------------------------------------(2)



(2) into (1)

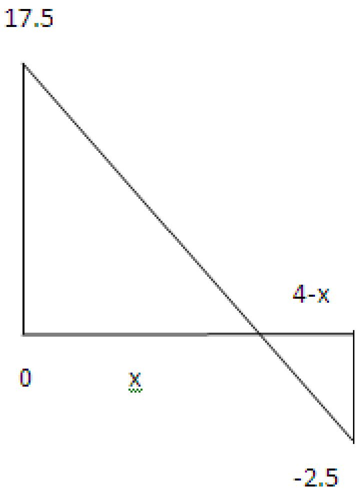
$F_A + F_D = 30$ kN

$F_A + 12.5 = 30$

$F_A = 30 – 12.5$

$F_A = 17.5$ kN

Shear force diagram.



$$\frac{x}{17.5} = \frac{4-x}{2.5}$$

$2.5(x) = (4 – x)\ 17.5$

$2.5x = 70 – 17.5x$

$2.5x + 17.5x = 70$

$20\,x = 70$

$x = 70/20$

$x = 3.5$

$M_A = 0$

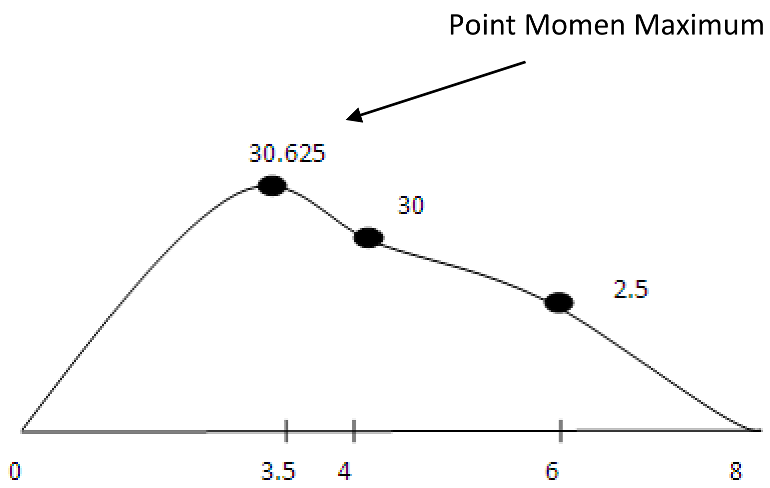
$M_1 = 17.5(3.5) - 5(3.5)\left(\frac{3.5}{2}\right) = 30.625$

$M_2 = 17.5(6) - 5(4)\left(\frac{4}{2}\right) = 30$

$M_3 = 17.5(6) - 5\left(\frac{4}{2} + 2\right) = 25$

$M_4 = 17.5(8) - 5(4)\left(\frac{4}{2} + 4\right) - 10(2) = 0$

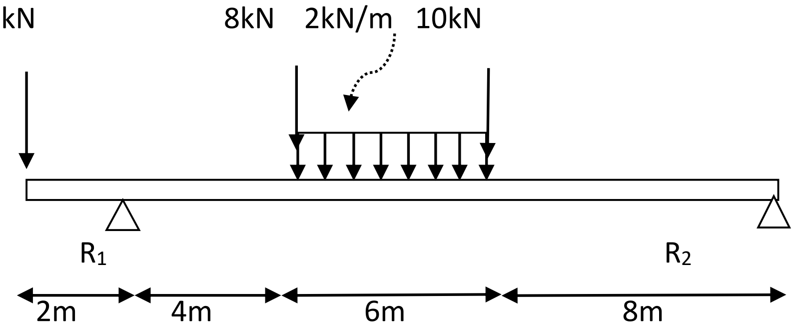
Bending moment diagram.



Value of momen maximum is 30.625.

EXERCISE

3. An overhanging beam is loaded as shown in Figure below.

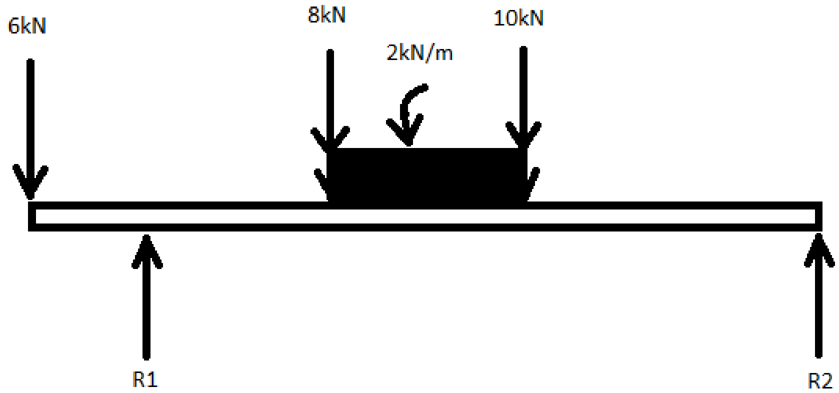


i) Sketch the body diagram of the beam and find reaction force at point R1 and R2

ii) Determine shear force and bending moment at each point of force on that beam.

iii) Determine the value of contra flexure by sketching the shear force diagram and bending moment diagram

SOLUTION



$\sum + M1 = 0$

$-6 (2) + 8(4) + 2(6)(7) + 10(10) - R2(18) = 0$

$204 - 18 R2 = 0$

$R2 = 11.33kN$

$\sum F = \sum F$

$R1 + R2 = 6 + 8 + 10 + 2 (6)$

$= 36$

$R1 + 11.33 = 36$

$R1 = 24.67kN$

Determine shear force and bending moment at each point of force on that beam

Shear force

VA = -6 kN

V1 = -6+24.67 =18.67 kN

VB = 18.67-8=10.67 kN

VBC = 10.67-2(6)=-1.33 kN

VC = -1.33 -10 =-11.33 kN

VD = -11.33 +11.33 = 0 kN

Bending moment

MA = 0

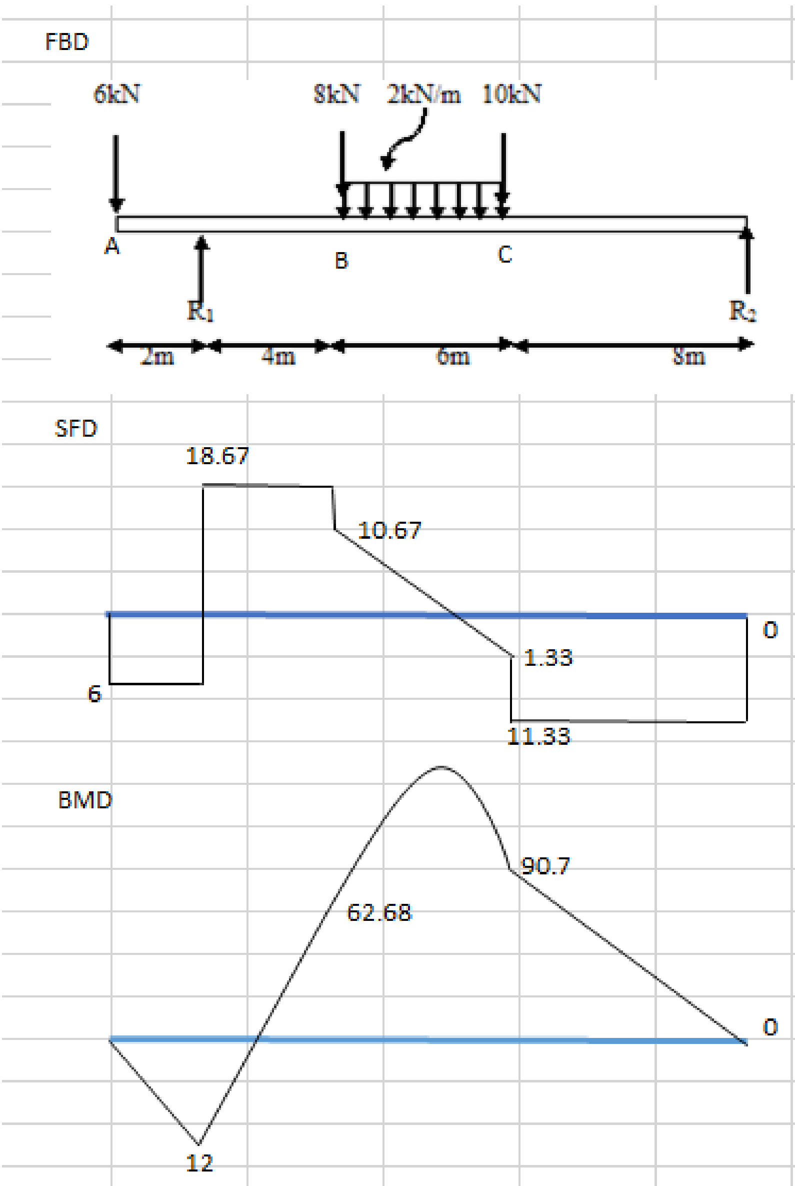
M1 = -6(2) = -12 KNm

MB = -6(6)+24.67(4)=62.68 KNm

MC = -6(12)+24.67(10) -8 (6)-2(6)(3)=90.7 KNm

M2 =-6(20)+24.67(18) -8 (14)-2(6)(11)-10(8)= 0

Determine the value of contra flexure by sketching the shear force diagram and bending moment diagram



$Mc = -6(2+x) + 24.67x$

$Mc = 0$

$-6(2+x) + 24.67x = 0$

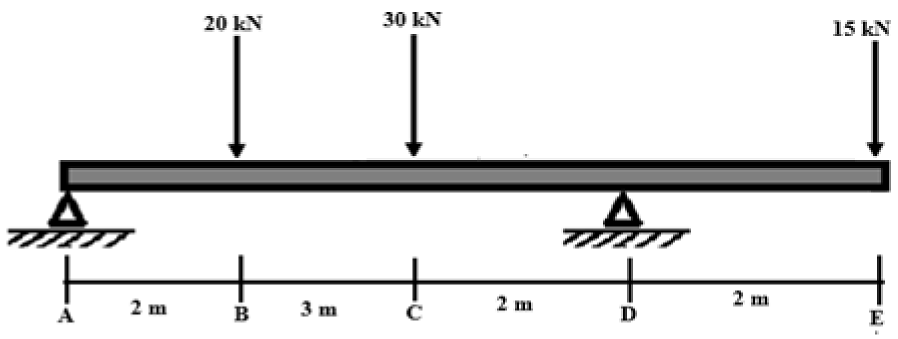
$-12 - 6x + 24.67x = 0$

$X = 0.64$

The point of contra flexure occur at 2.64m from point A

EXERCISE

4. The figure below shows that an overhanging beam has 3-pointed load at positioned 2m, 5m from A and at the end of the beam.



i) Identify the reaction force at the support of A and D

ii) Determine the shear force and bending moment at point ABCDE

iii) Sketch the shear force and bending moment diagram

iv) Determine the contra flexure point from point A

SOLUTION

Consider moment at point D and A,

$$\sum M_D = 0$$
$$R_A(7) + (15\times 2) = (30\times 2) + (20\times 5)$$
$$\therefore R_A = 18.571\,\text{kN}$$

$$\sum M_A = 0$$
$$R_D(7) = (20\times 2) + (30\times 5) + (15\times 9)$$
$$\therefore R_D = 46.429\,\text{kN}$$

Shear Force

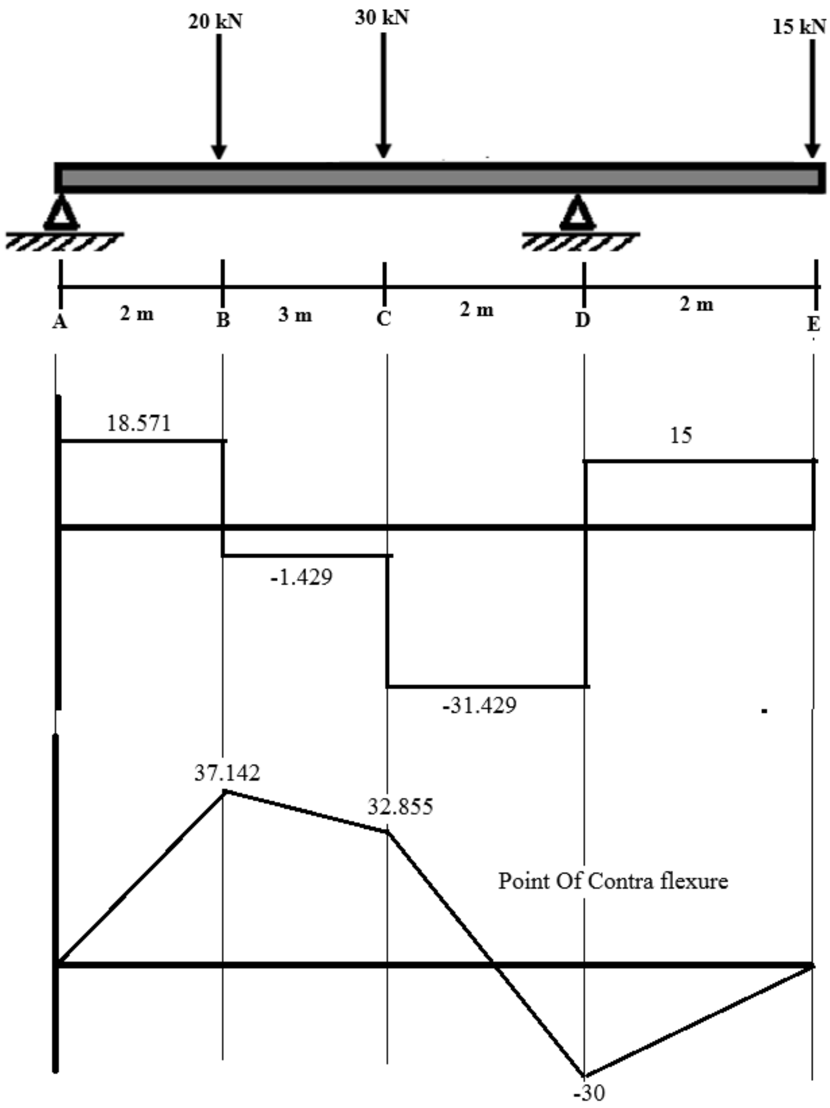
$$V_A = 18.571\,\text{kN}$$
$$V_B = 18.571 - 20 = -1.429\,\text{kN}$$
$$V_C = -1.429 - 30 = -31.429\,\text{kN}$$
$$V_D = -31.429 + 46.429 = 15\,\text{kN}$$
$$V_E = 15 - 15 = 0$$

Area Under Graph

$$A_1 = 18.571\times 2 = 37.142\,\text{kNm}$$
$$A_2 = -1.429\times 3 = -4.287\,\text{kNm}$$
$$A_3 = -31.429\times 2 = -62.858\,\text{kNm}$$
$$A_4 = 15\times 2 = 30\,\text{kNm}$$

Bending Moment

$$M_A = 0$$
$$M_{A-B} = 37.142\,\text{kNm}$$
$$M_{B-C} = 37.142 - 4.287 = 32.855\,\text{kNm}$$
$$M_{C-D} = 32.855 - 62.858 = -30\,\text{kNm}$$
$$M_{D-E} = -30 + 30 = 0$$



Contraflexure

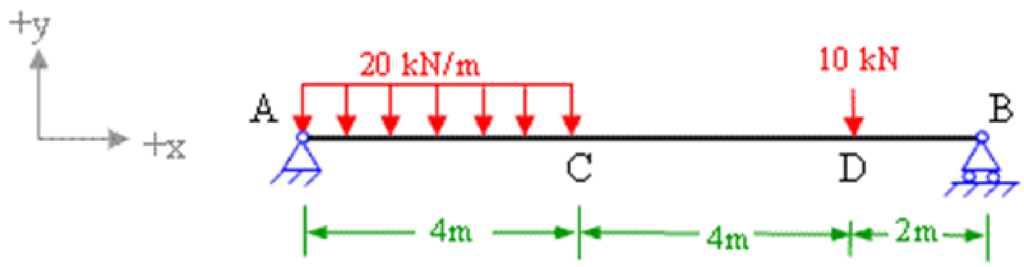
Given "x" distance from point C. Thus, the point of contra flexure can be calculated as;

$$18.571(x+5) - 20(30 \times x) = 0$$
$$18.571x + 92.855 - 20x - 60 - 30x = 0$$
$$31.429x = 32.855 \quad x = 1.045\,\text{m} \quad (\text{Answer})$$

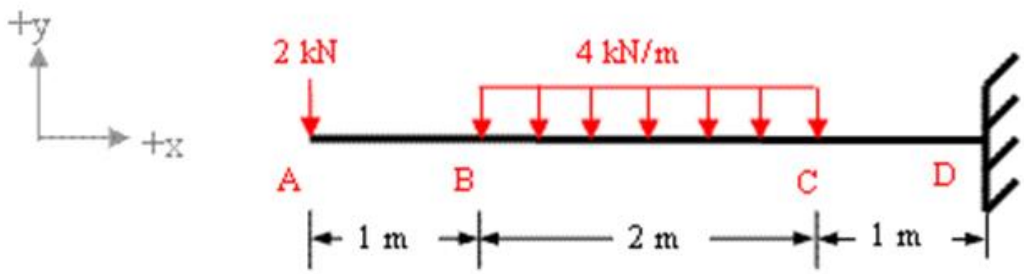
3.1 EXERCISE

***Instructions**:* Answer all of the following questions.

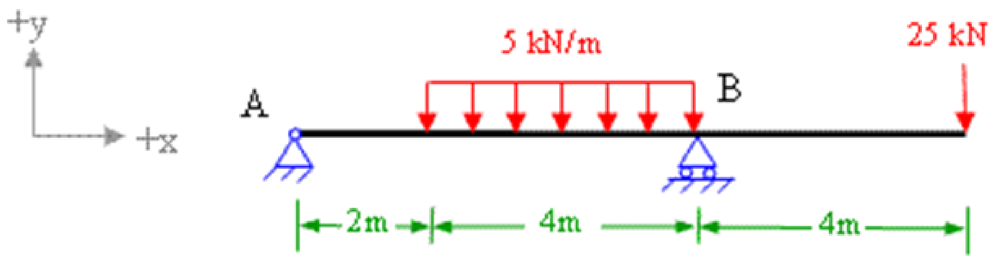
1. Define shear force and bending moment.
2. Define the sign conversion for shear force and bending moment.
3. Calculate the value and draw a bending moment and shear force diagram for the beam shown in fig below.



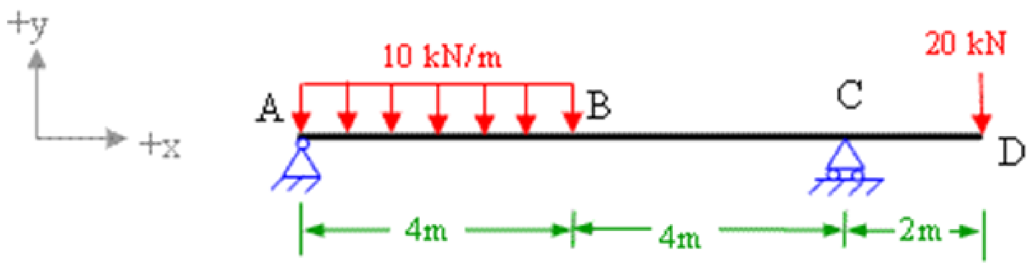
4. Calculate the value and draw a bending moment and shear force diagram for the cantilever beam shown in fig below.



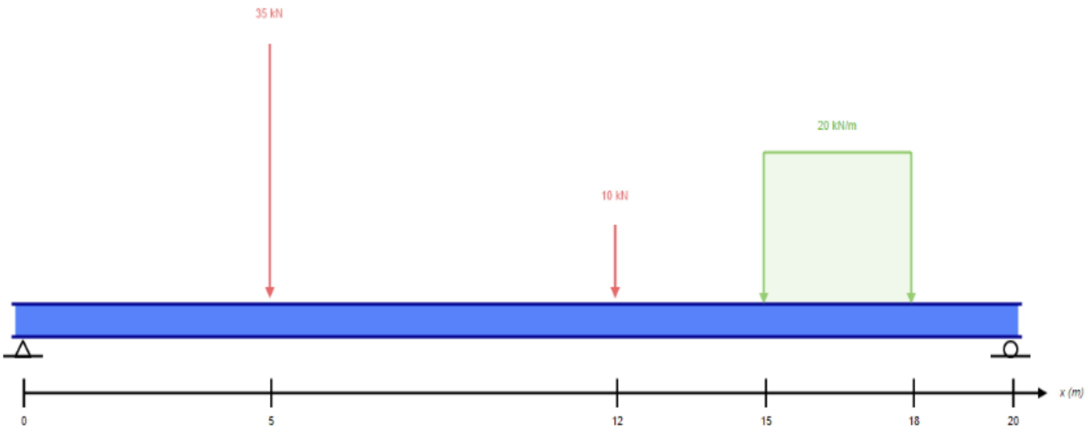
5. Calculate the value and draw a bending moment and shear force diagram for the following overhanging beam shown in fig.



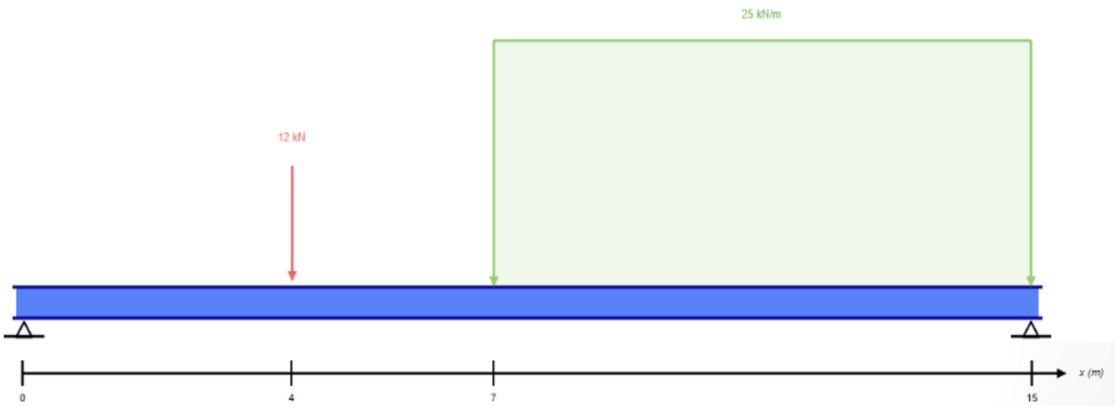
6. Calculate the value and draw a bending moment and shear force diagram for the following beam shown in fig and find the point of contraflexure.



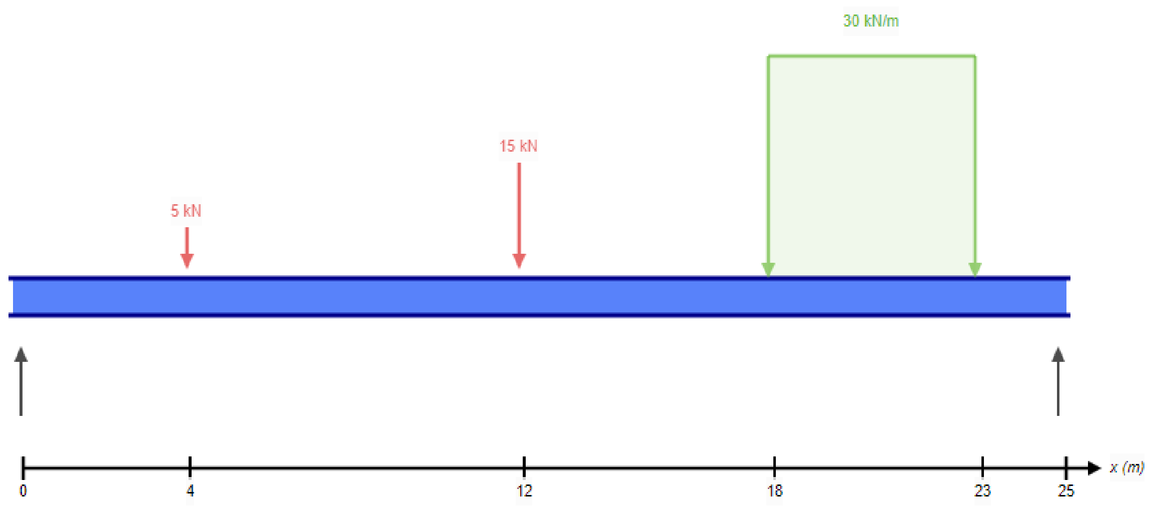
7. Calculate the value and draw a bending moment and shear force diagram for the following overhanging beam shown in fig.



8. Calculate the value and draw a bending moment and shear force diagram for the following overhanging beam shown in fig.



9. Calculate the value and draw a bending moment and shear force diagram for the following overhanging beam shown in fig.



REFERENCES

William, B. *at all* (2022, March 14). Shear Force and Bending Moment. CodeCogs. https://www.codecogs.com/library/engineering/materials/shear-force-and-bending-moment.php

William, B. *at all* (2022, March 14). Shear Force and Bending Moment. CodeCogs. https://www.codecogs.com/users/23573/0001.jpg

Siti Hanis, at all (2017, Dicember). *Strength of Materials. Second Edition Malaysian Polytechnics.* Politeknik Nilai

Ros Saidatunnaziah, at all (2015, Dicember). *Strength of Materials. First Edition in SI Units Malaysian Polytechnics.* Politeknik Port Dickson

Shear Force and Bending Moment. CodeCogs. https://ocw.nthu.edu.tw/ocw/upload/8/253/Chapter_4-98.pdf

Shear force and bending moment diagram CodeCogs. https://sites.google.com/site/mechanicalstuff4u/contents-of-m/strength-of-materials/shear-force-and-bending-moment-diagram

e ISBN 978-967-0838-81-6

9 7 8 9 6 7 0 8 3 8 8 1 6

SHEAR FORCE AND
BENDING MOMENT

POLITEKNIK MELAKA
NO. 2, JALAN PPM 10,
PLAZA PANDAN MALIM
75250 MELAKA
TEL: 063376000