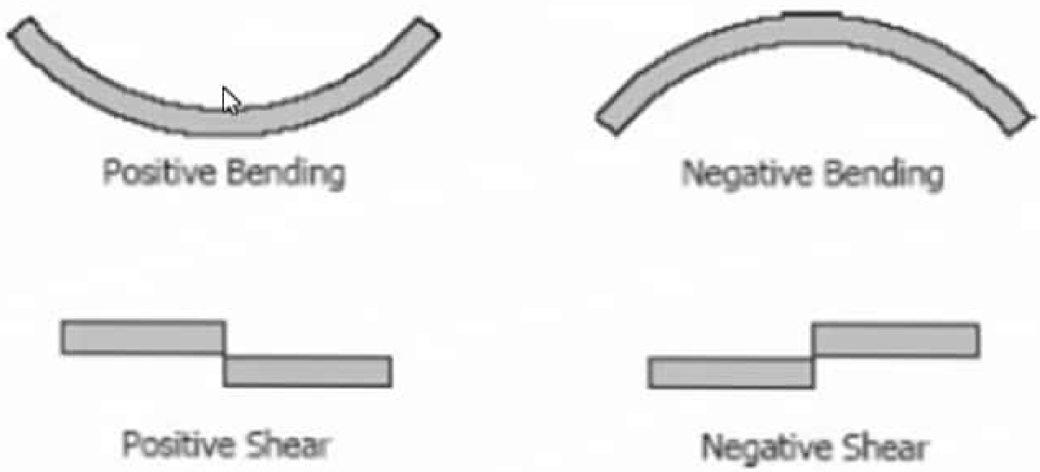
Shear Force and Bending Moment

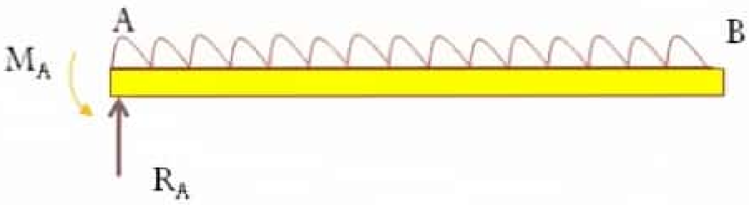
- The algebraic sum of the vertical forces at any section of a beam to the right or left of the section is known as shear force
- A shear force diagram (SFD) is one which shows the variation of shear force along the length of the beam.
- The algebraic sum of the moments of all the forces acting to the right or left of any section of a beam is known as bending moment
- A bending moment diagram (BMD) is one which shows the variation of bending moment along the length of the beam.

Guidelines for drawing SFD and BMD

- Consider left or right portion of the section
- Add the forces normal to the beam on one of the portion. If right portion of the section is chosen, a force on the right portion acting downward is positive while a force acting upward is downward
- The positive values of shear force and bending moments are plotted above the base line and negative values below the base line
- The shear force diagram increase or decrease suddenly i.e. by vertical straight line at a section where there is a vertical point load
- The shear force between any two vertical loads will be constant and hence the shear force diagram between two vertical loads will be horizontal
- Bending moment at any hinge or roller support, at the end of beam, is zero

SIGN CONVENTIONS





$R_A = wL$

$M_A = wL^2/2$

Shear force at any section x from right end $V_x = wx$

Bending moment at any section x from right end $M_x = wx*x/2 = wx^2/2$

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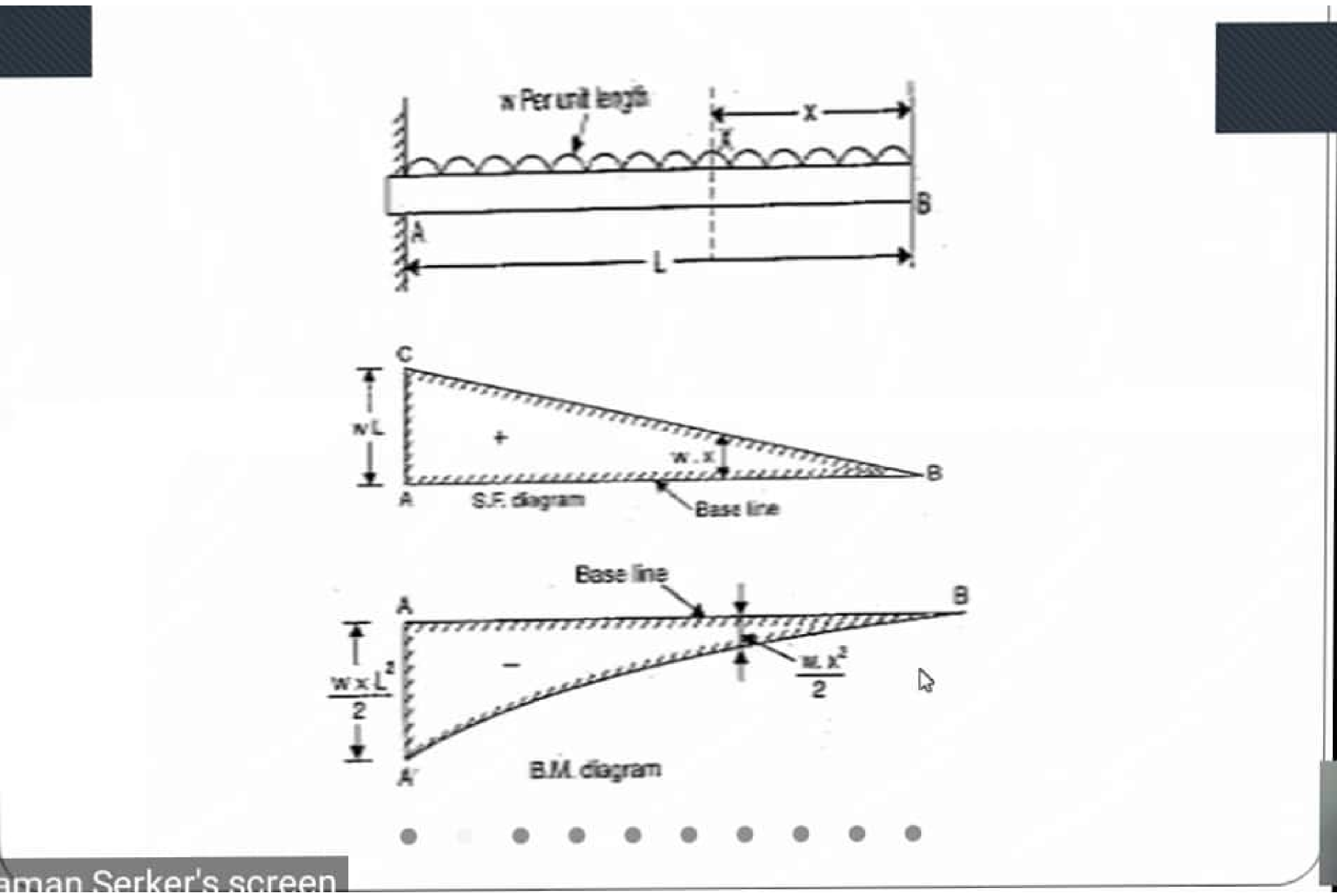
w Per unit length
x
X
A
B
L
C
wL
+
w.x
A
B
S.F. diagram
Base line
Base line
A
B
w x L²/2
−
w.x²/2
A'
B.M. diagram
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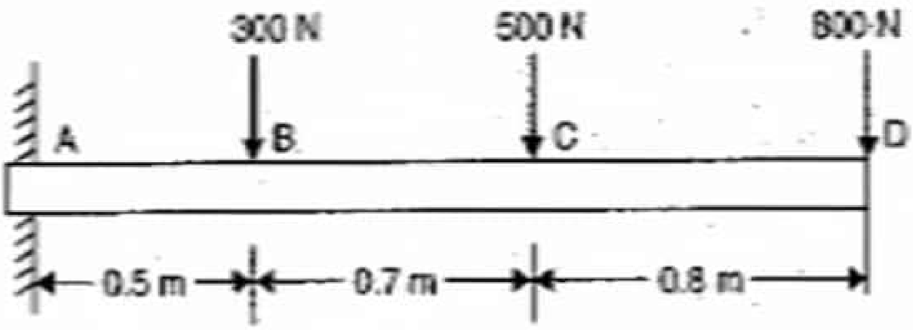
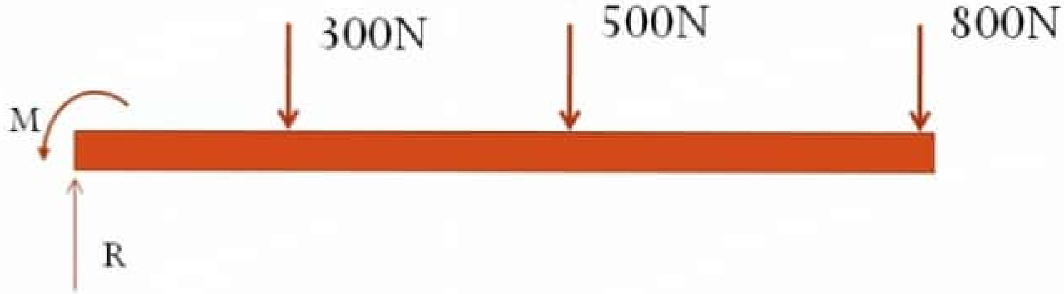
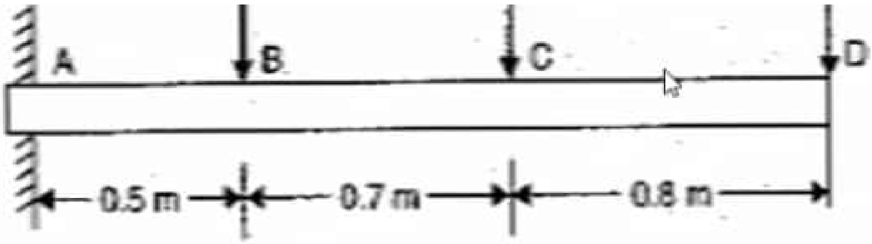
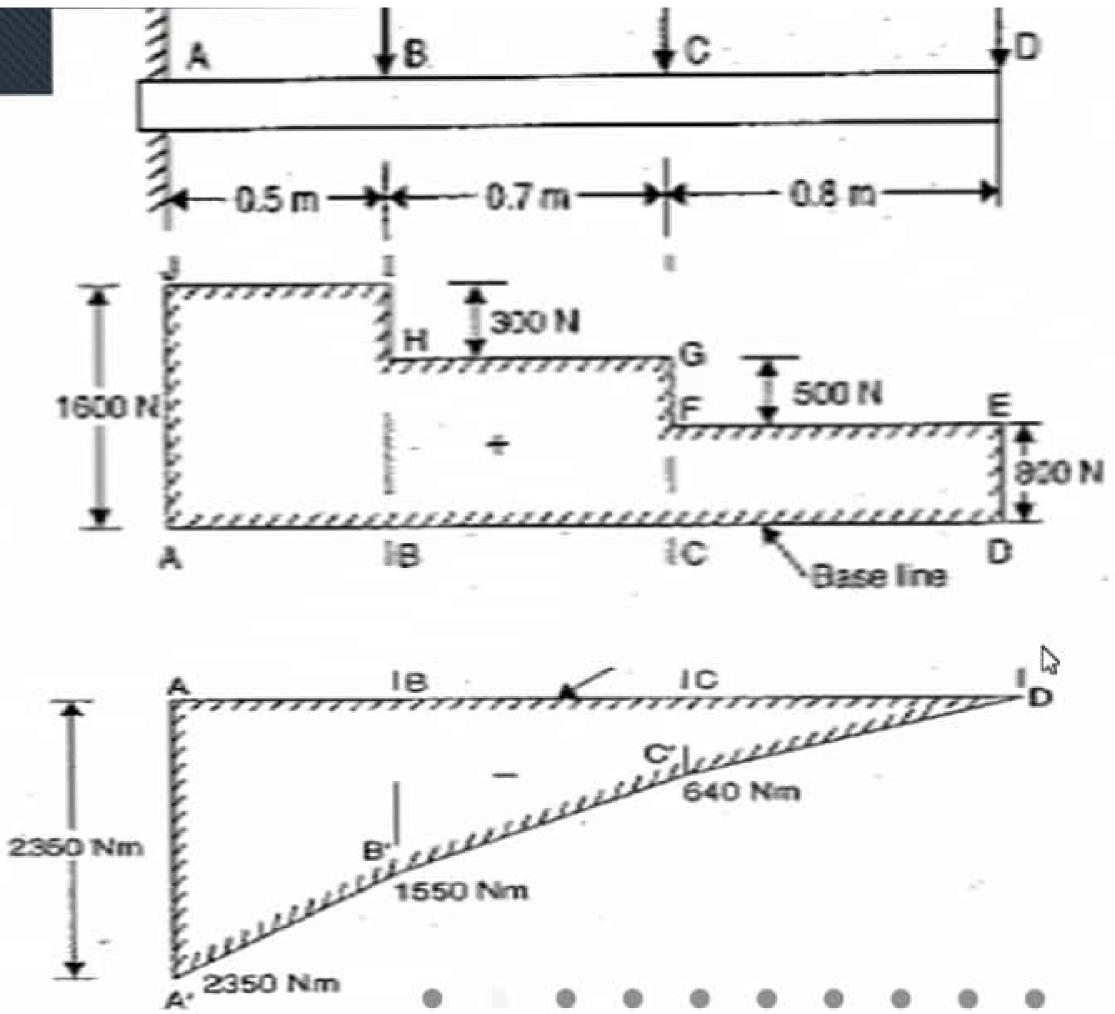




$$R = 1600 \text{ N}$$
$$M = 2350 \text{ N-m}$$

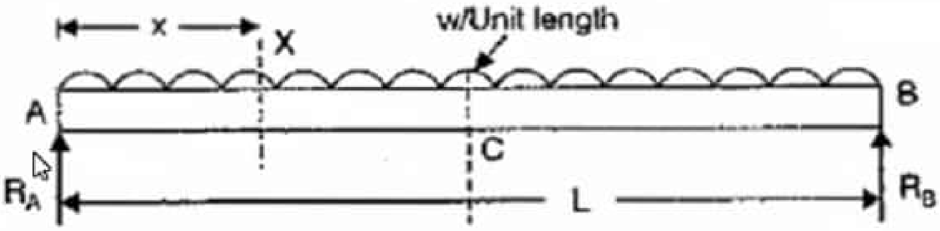


- Shear force at D V_D = 800N
- Shear force at C V_C = 800N + 500N = 1300N
- Shear force at B V_B = 800N+500N+300N = 1600N
- Shear force at A V_A = +1600N
- Bending moment at the free end D is zero
- Bending moment between D and C at a distance x from D M_x = -800*x
- At C, x = 0.8m M_C = -800*0.8 = 640N-m
- Bending moment between B and C at a distance x from D M_x = -800*x – 500(x-0.8)
- Bending moment between B and A at a distance x from D M_x = -800*x – 500(x-0.8) – 300(x-1.5)

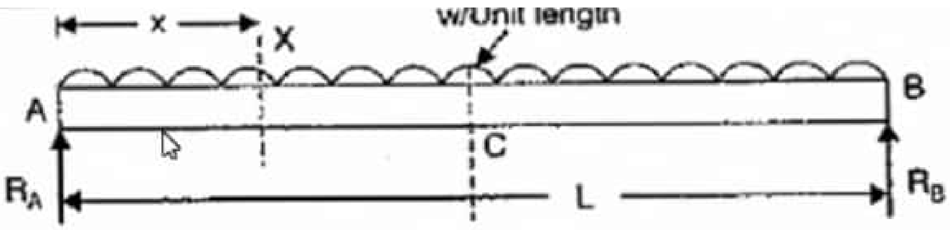


A
B
C
D
0.5 m
0.7 m
0.8 m
300 N
H
G
500 N
1600 N
F
E
+
800 N
A
B
C
Base line
D
A
B
C
D
C'
640 Nm
2350 Nm
B'
1550 Nm
A'
2350 Nm

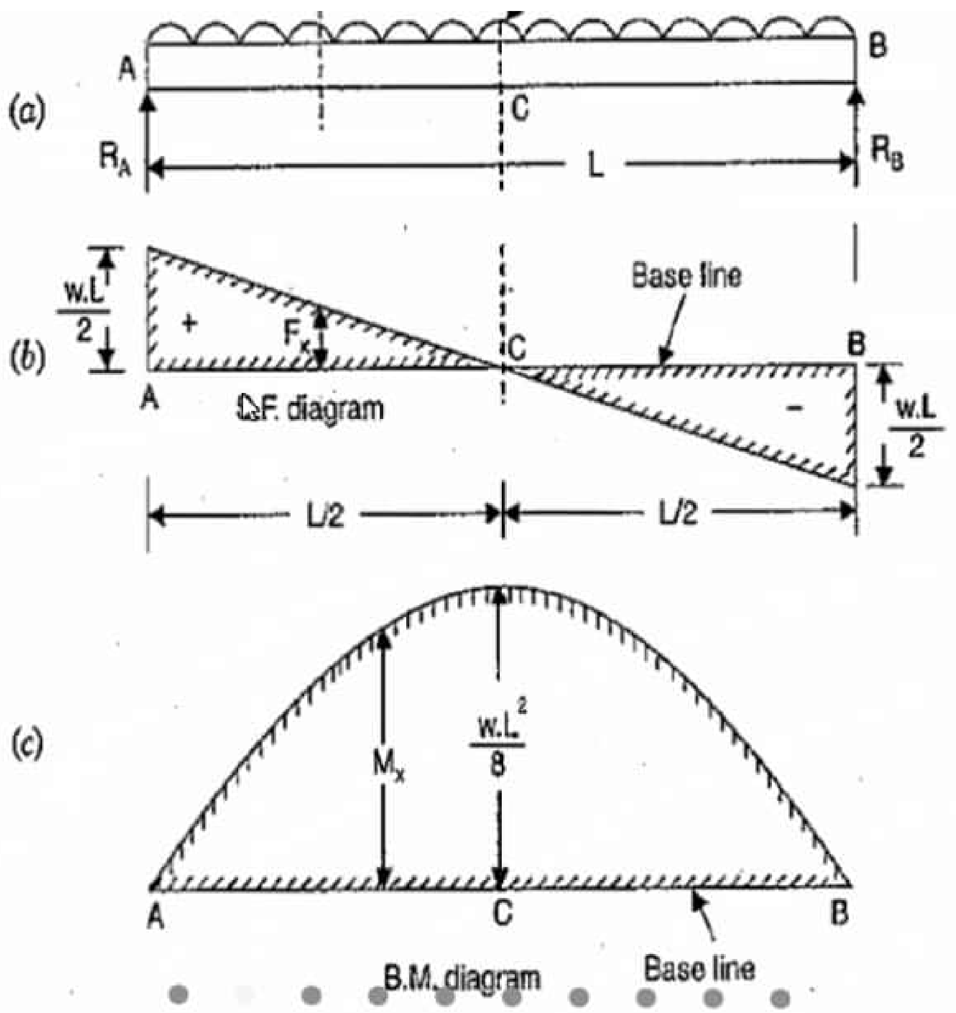
Supported Beam



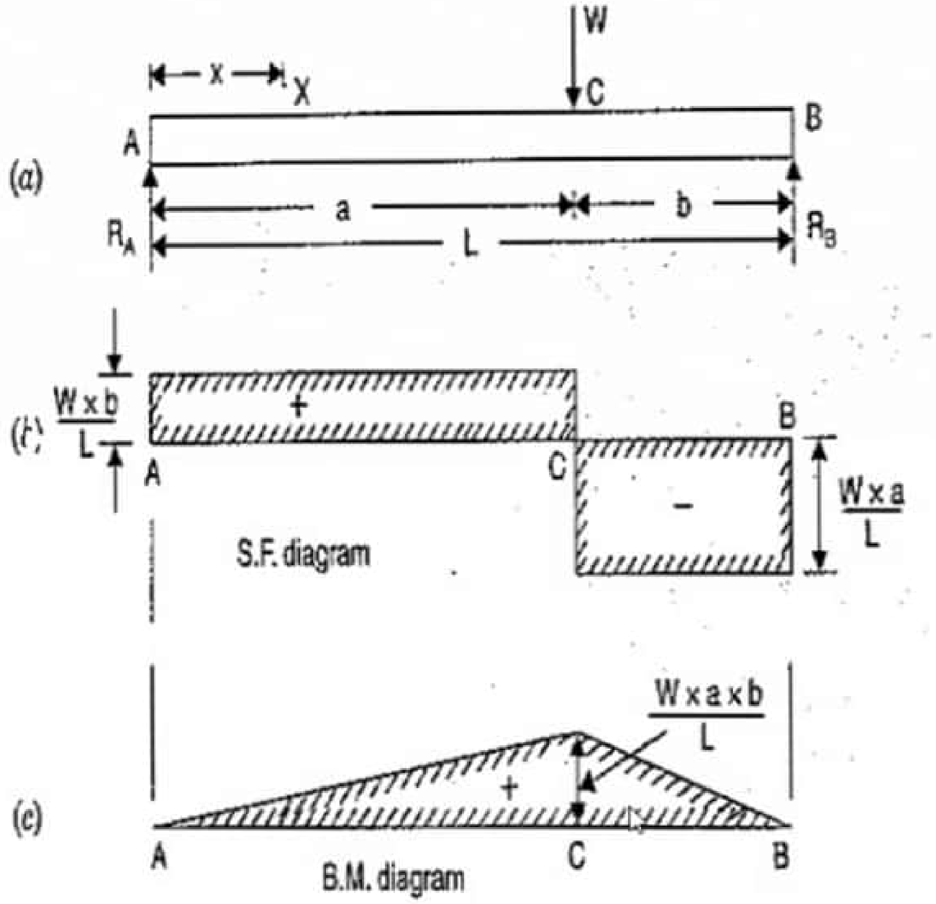
$$R_A = R_B = wL/2$$



- Consider any section at distance x from left support $V_x = R_L - w*x = wL/2 - w*x$
- At A, x=0 => $V_A = wL/2$
- At B, x=L => $V_B = -wL/2$
- At C, x = L/2 => Vc = 0



(a)
A
B
C
R_A
R_B
L
(b)
w.L
2
+
F_x
C
Base line
B
A
S.F. diagram
-
w.L
2
L/2
L/2
(c)
M_x
w.L²
8
A
C
B
B.M. diagram
Base line



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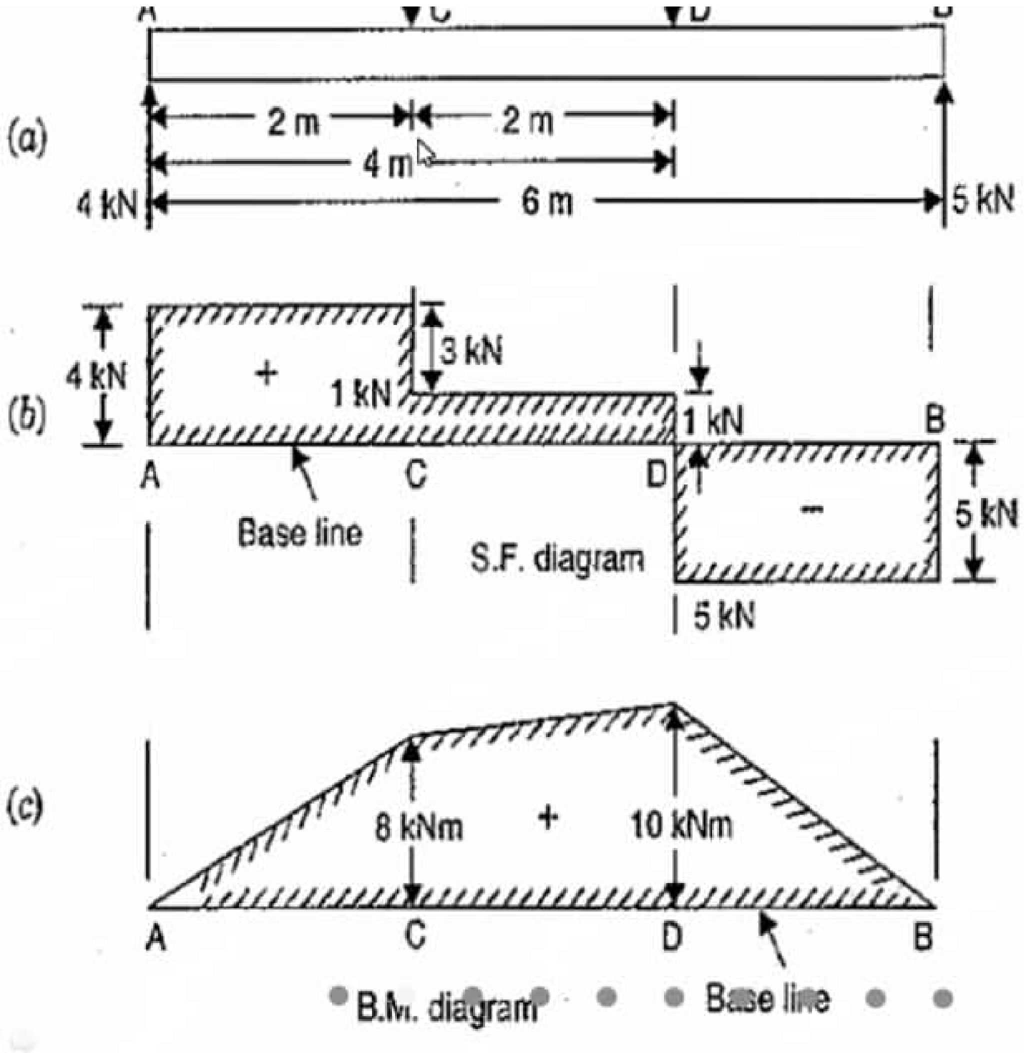
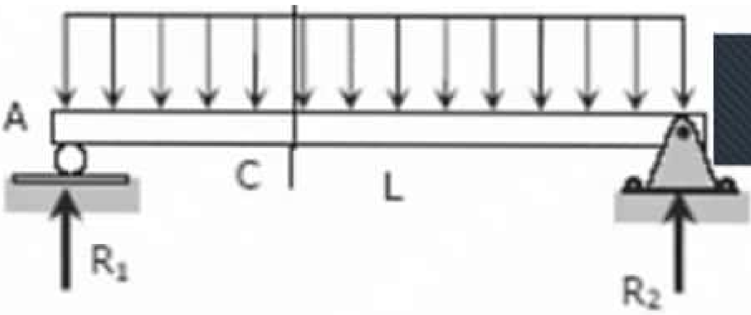
DIAGRAMS

- The following are some important properties of shear and moment diagrams:
- The area of the shear diagram to the left or to the right of the section is equal to the moment at that section.
- The slope of the moment diagram at a given point is the shear at that point.
- The slope of the shear diagram at a given point equals the load at that point.
- The maximum moment occurs at the point of zero shears.
- When the shear diagram is increasing, the moment diagram is concave upward.
- When the shear diagram is decreasing, the moment diagram is concave

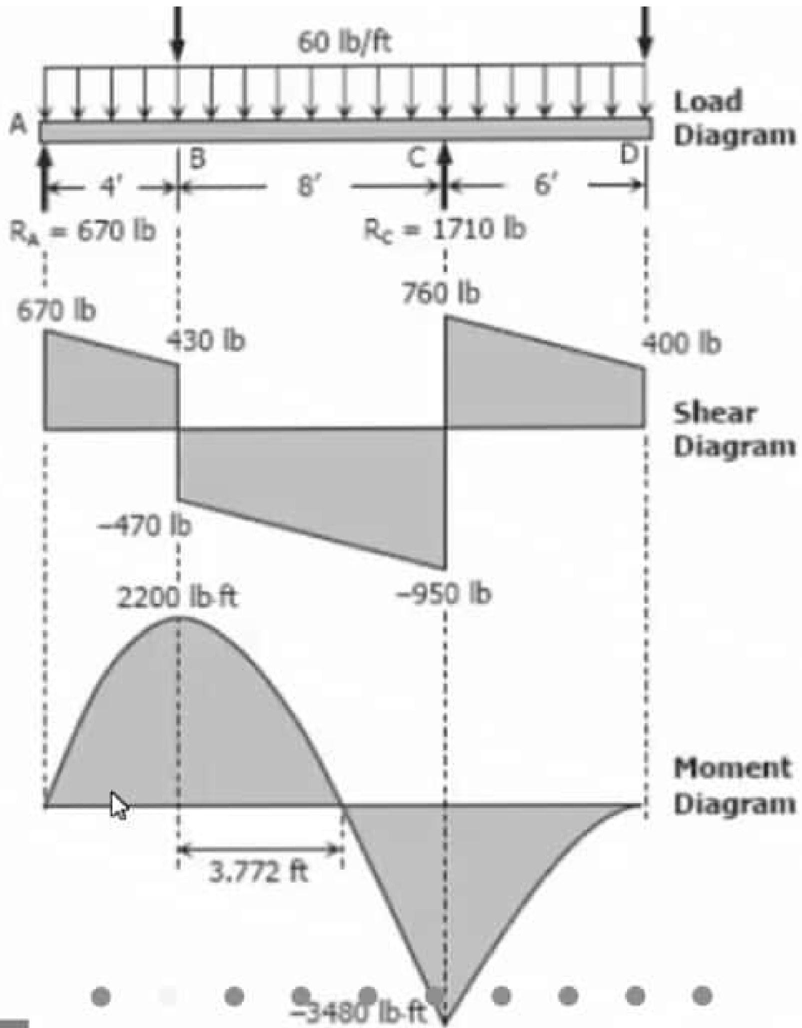


(a)
2 m
2 m
4 m
6 m
4 kN
5 kN
(b)
4 kN
+
3 kN
1 kN
1 kN
B
A
C
D
−
5 kN
Base line
S.F. diagram
5 kN
(c)
8 kNm
+
10 kNm
A
C
D
B
B.M. diagram
Base line



- $V_x = R_1 - wx = wL/2 - wx$
- $M_x = R_1 * x - w * x^2/2$
- $M_x = wLx/2 - w * x^2/2$
- Differentiate M with respect to x

$$\frac{dM}{dx} = \frac{wL}{2}\frac{dx}{dx} - \frac{w}{2}2x\frac{dx}{dx} \qquad \Rightarrow \frac{dM}{dx} = \frac{wL}{2} - wx$$



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