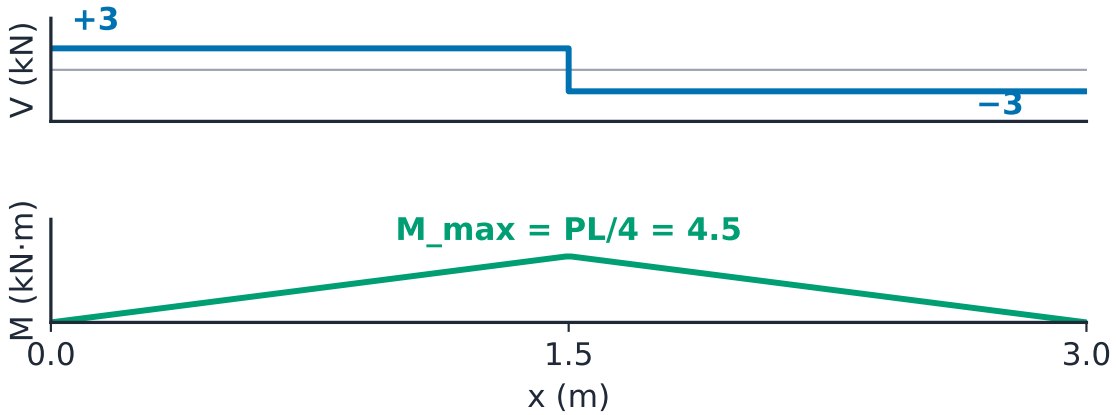
Exercise walk-through

6.3
Shear and bending

University Mechanical Engineering

Shear and bending: the diagrams

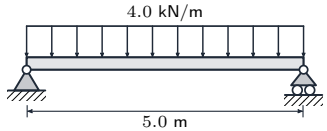
central load: P = 6 kN on a 3 m span, reactions 3 kN each



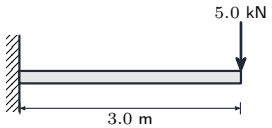
Central $P = 6$ kN on 3 m: reactions 3 kN, V steps $+3 \to -3$ kN, $M_{max} = PL/4 = \mathbf{4.5}$ kN · m. Uniform $w = 2$ kN/m: $M_{max} = wL^2/8 = \mathbf{2.25}$ kN · m.

Exercises 2.1·2.2

2.1 A simple beam of span 5.0 m carries a UDL of 4.0 kN/m. Find the reactions and the largest moment, and sketch V and M. [3]

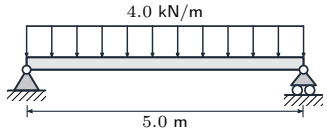


2.2 A 3.0 m cantilever carries 5.0 kN at its free end. Find V and M along it, and the moment at the wall. [2]



Exercises 2.1·2.2

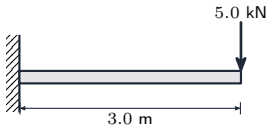
2.1 A simple beam of span 5.0 m carries a UDL of 4.0 kN/m. Find the reactions and the largest moment, and sketch V and M. [3]



2.1

$R_A = R_B =$ **10 kN**; V falls linearly from +10 to −10 kN; $M_{max} = \dfrac{4 \times 25}{8} =$ **12.5 kN m** at mid-span, a parabola

2.2 A 3.0 m cantilever carries 5.0 kN at its free end. Find V and M along it, and the moment at the wall. [2]



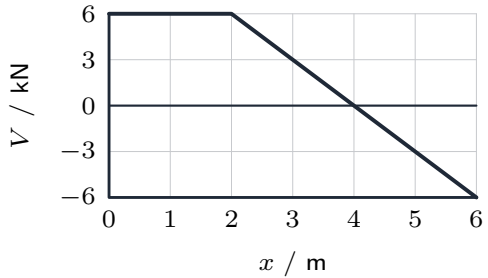
2.2

$V = 5.0$ kN all along; $M = -5x$, so **−15 kN m** at the wall (hogging)

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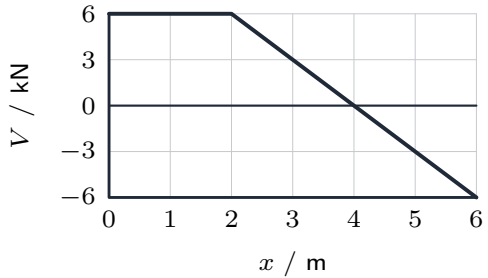
Exercise 2.3

2.3 The figure shows the shear force diagram of a simple beam of span 6 m. Describe the loading, and find the largest moment and where it acts. [3]



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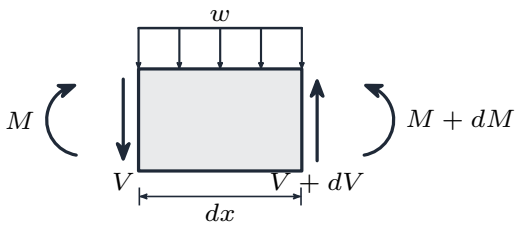


2.3

reactions 6 kN at each end; no load from 0 to 2 m; a UDL of $\dfrac{12}{4} = 3$ kN/m from 2 to 6 m; $V = 0$ at $x = 4$ m: $M_{max} = 6 \times 2 + \frac{1}{2} \times 2 \times 6 = \mathbf{18\ kN\ m}$

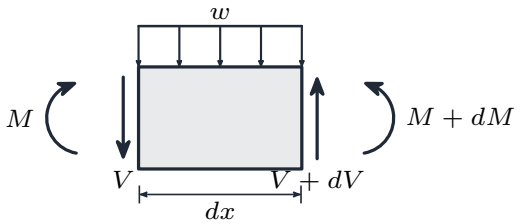
Exercise 2.4

2.4 Use a small beam element of length dx with a distributed load w to show that $\dfrac{dM}{dx} = V$. [3]



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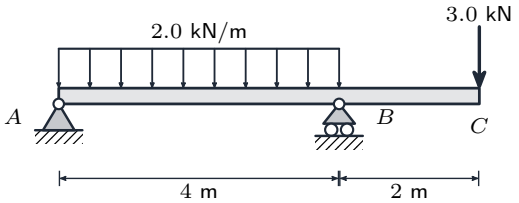
2.4

moments about the right face: $M + dM - M - V\,dx + w\,dx\dfrac{dx}{2} = 0$; the dx^2 term is negligible; so $dM = V\,dx$, $\dfrac{dM}{dx} = V$

Exercise 3.1

3.1 A beam is supported at A ($x = 0$) and B ($x = 4$ m) and overhangs to C ($x = 6$ m). It carries a UDL of 2.0 kN/m from A to B and a point load of 3.0 kN at C.

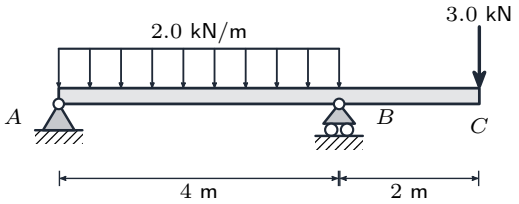
Find the reactions. Sketch V and M, find the largest positive and negative moments, and the point of contraflexure . [6]



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3.1

moments about A: $4R_B = 8 \times 2 + 3 \times 6$, $R_B = \mathbf{8.5\ kN}$, $R_A = \mathbf{2.5\ kN}$

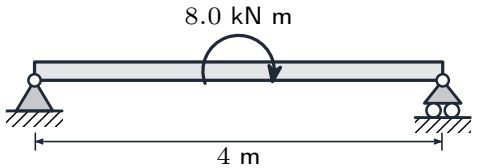
V: 2.5 falling to -5.5 kN at B, jump to $+3.0$, constant to C

$V = 0$ at $x = 1.25$ m: $M = +\mathbf{1.56\ kN\ m}$; at B: $M = -3 \times 2 = \mathbf{-6.0\ kN\ m}$

$M = 2.5x - x^2 = 0$ at $x = \mathbf{2.5\ m}$

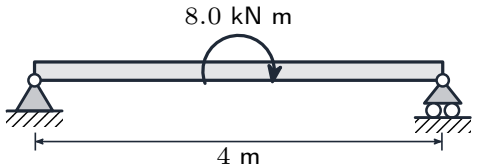
Exercise 3.2

3.2 A simple beam of span 4 m carries only a clockwise couple of 8.0 kN m at mid-span. Find the reactions, and sketch V and M. [3]



Exercise 3.2

3.2 A simple beam of span 4 m carries only a clockwise couple of 8.0 kN m at mid-span. Find the reactions, and sketch V and M. [3]



3.2

$4R_B = 8$: $R_B = 2$ kN up, $R_A = 2$ kN down; $V = -2$ kN everywhere; M falls to -4 kN m, jumps by 8 to $+4$ kN m at the couple, then back to 0

Exercise 3.3 (a)

3.3 A timber floor joist spans 4.0 m (simply supported). It carries the floor as a UDL of 2.5 kN/m, and a heavy 4.0 kN cabinet that may stand anywhere. Allowable bending stress 10 MPa; the joist is 75 mm wide.

(a) Find the largest moment with the cabinet at mid-span. [2]

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3.3 A timber floor joist spans 4.0 m (simply supported). It carries the floor as a UDL of 2.5 kN/m, and a heavy 4.0 kN cabinet that may stand anywhere. Allowable bending stress 10 MPa; the joist is 75 mm wide.

(a) Find the largest moment with the cabinet at mid-span. [2]

(a) $M = \dfrac{wL^2}{8} + \dfrac{PL}{4} = 5.0 + 4.0 = \mathbf{9.0\ kN\ m}$

Exercise 3.3 (b)

3.3 A timber floor joist spans 4.0 m (simply supported). It carries the floor as a UDL of 2.5 kN/m, and a heavy 4.0 kN cabinet that may stand anywhere. Allowable bending stress 10 MPa; the joist is 75 mm wide.

(b) Show that mid-span is the worst place for the cabinet. [2]

Exercise 3.3 (b)

3.3 A timber floor joist spans 4.0 m (simply supported). It carries the floor as a UDL of 2.5 kN/m, and a heavy 4.0 kN cabinet that may stand anywhere. Allowable bending stress 10 MPa; the joist is 75 mm wide.

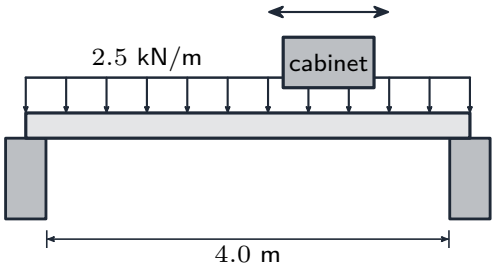
(b) Show that mid-span is the worst place for the cabinet. [2]

(b) with the cabinet at a: $M(a) = \dfrac{w}{2}a(L-a) + \dfrac{P}{L}a(L-a)$; both terms are largest at $a = L/2$

Exercise 3.3 (c)

3.3 A timber floor joist spans 4.0 m (simply supported). It carries the floor as a UDL of 2.5 kN/m, and a heavy 4.0 kN cabinet that may stand anywhere. Allowable bending stress 10 MPa; the joist is 75 mm wide.

(c) Find the section modulus needed, the depth h ($S = \frac{1}{6}bh^2$), and choose a standard depth from 225, 250, 275 and 300 mm. [4]

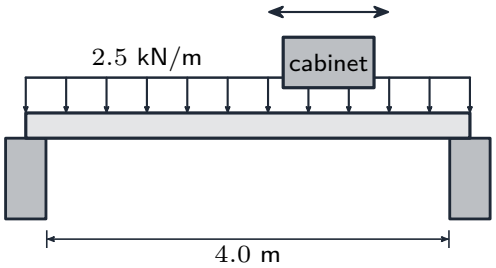


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Exercise 3.3 (c)

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(c) $S \geq \dfrac{9.0 \times 10^6}{10} = 9.0 \times 10^5$ mm^3; $h \geq \sqrt{\dfrac{6 \times 9.0 \times 10^5}{75}} =$ **268 mm**; choose **75 × 275 mm**