Department of Mechanical Engineering (NITC)

S1ME **ZZ1001D ENGINEERING MECHANICS** **Tutorial Test 3-Set1**

Time: One Hour **Answer Key** Maximum Marks: 20

1. Estimate the supporting force system at the end A for the cantilever beam shown in Fig. 1. Neglect the weight of the beam.

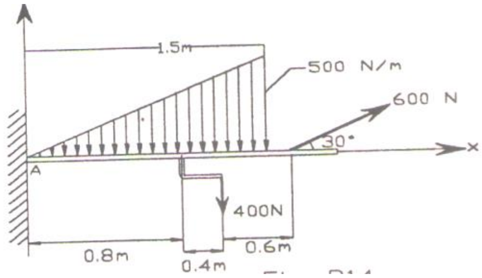


Figure 1

Solution:

4)

$\xrightarrow{+} \Sigma F_x = 0$

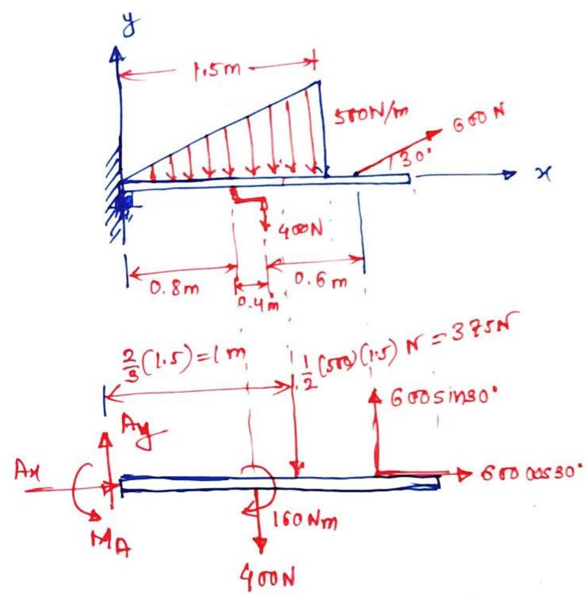
$\Rightarrow A_x + 600\cos 30^\circ = 0$

$\Rightarrow A_x = -519.615\ N$

$+\uparrow \Sigma F_y = 0$

$\Rightarrow A_y - 375 - 400 + 600\sin 30^\circ = 0$

$\Rightarrow A_y = 775 - 300 = 475\ N$



$\circlearrowleft + \Sigma M_A = 0$

$\Rightarrow M_A - 160 - (0.8)(400) - 1(375) + 1.8(600\sin 30^\circ) = 0$

$\Rightarrow M_A = 160 + 320 + 375 - 540$

$= 315\ N.m$

2. Locate the centroid of the shaded area shown in Fig. 2.

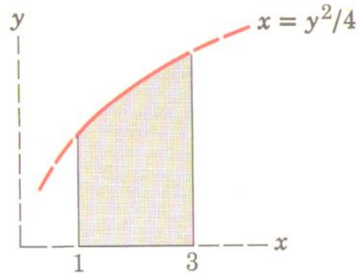
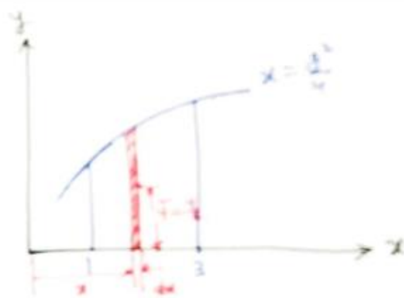


Figure 2



2.7) $dA = y\,dx = 2\sqrt{x}\,dx$

$A = \int_1^3 2\sqrt{x}\,dx = 2\cdot\frac{2}{3}\, x^{3/2}\Big|_1^3$

$= \frac{4}{3}\left(3^{3/2} - 1\right)$

$= 5.595$

$x_c = \dfrac{\int \tilde{x}\,dA}{\int dA} = \dfrac{\int_1^3 2x^{3/2}\,dx}{5.595}$

$= \frac{2}{5.595}\cdot\frac{2}{5}\left(3^{5/2} - 1\right)$

$x_c = 2.086$ unit

$y_c = \dfrac{\int \tilde{y}\,dA}{\int dA} = \dfrac{\int_1^3 \frac{y}{2}\,dA}{5.595} = \dfrac{\frac{1}{2}\int_1^3 y^2\,dx}{5.595} = \dfrac{2\int_1^3 x\,dx}{5.595}$

$= \frac{2}{5.595}\cdot\frac{1}{2}\left(3^2 - 1\right) = \frac{8}{5.595}$

$y_c = 1.43$ unit

3. The stock mounted on the lathe is subjected to a force of 60N. Determine the coordinate direction angle and express the force as a Cartesian vector.

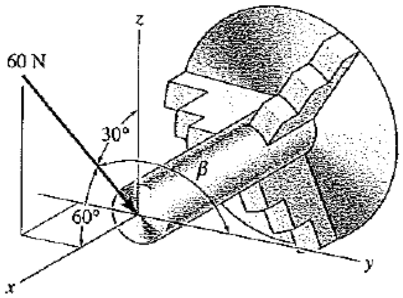
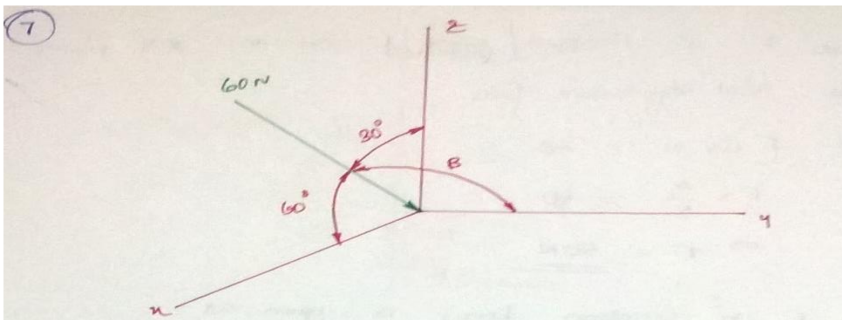


Figure 3



$$\vec{F} = 60\left[\cos\alpha\, i + \cos\beta\, j + \cos\gamma\, k\right]$$

$$= 60\left[\cos 60\, i + F_y j + \cos 30\, k\right]$$

$$\vec{F} = 30 i + F_y j + 52 k$$

Given that, $|\vec{F}| = 60$

$$\Rightarrow 3600 = 900 + F_y^2 + 52^2$$

$$\Rightarrow F_y = 0$$

$$\cos\beta = \frac{F_y}{F} = 0$$

$$\Rightarrow \beta = 90^\circ$$

$$\boxed{\vec{F} = 30 i + 52 k}$$

4. Determine the magnitude and location of the resultant hydrostatic force acting on the submerged rectangular plate *AB* shown in Fig. 4. The plate has a width of 1.5 m density = 1000 kg/m^3 Fig 4?

EXAMPLE 9.14

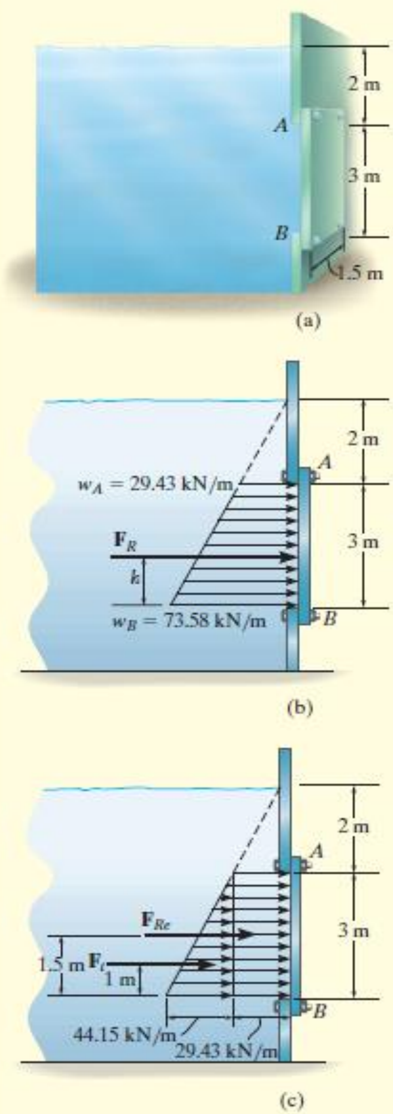


Fig. 9–28

Determine the magnitude and location of the resultant hydrostatic force acting on the submerged rectangular plate *AB* shown in Fig. 9–28*a*. The plate has a width of 1.5 m; $\rho_w = 1000\ \text{kg/m}^3$.

SOLUTION I

The water pressures at depths *A* and *B* are

$$p_A = \rho_w g z_A = (1000\ \text{kg/m}^3)(9.81\ \text{m/s}^2)(2\ \text{m}) = 19.62\ \text{kPa}$$

$$p_B = \rho_w g z_B = (1000\ \text{kg/m}^3)(9.81\ \text{m/s}^2)(5\ \text{m}) = 49.05\ \text{kPa}$$

Since the plate has a constant width, the pressure loading can be viewed in two dimensions as shown in Fig. 9–28*b*. The intensities of the load at *A* and *B* are

$$w_A = bp_A = (1.5\ \text{m})(19.62\ \text{kPa}) = 29.43\ \text{kN/m}$$

$$w_B = bp_B = (1.5\ \text{m})(49.05\ \text{kPa}) = 73.58\ \text{kN/m}$$

From the table on the inside back cover, the magnitude of the resultant force $\mathbf{F}_R$ created by this distributed load is

$$F_R = \text{area of a trapezoid} = \tfrac{1}{2}(3)(29.4 + 73.6) = 154.5\ \text{kN} \qquad \textit{Ans.}$$

This force acts through the centroid of this area,

$$h = \frac{1}{3}\left(\frac{2(29.43) + 73.58}{29.43 + 73.58}\right)(3) = 1.29\ \text{m} \qquad \textit{Ans.}$$

measured upward from *B*, Fig. 9–31*b*.

SOLUTION II

The same results can be obtained by considering two components of $\mathbf{F}_R$, defined by the triangle and rectangle shown in Fig. 9–28*c*. Each force acts through its associated centroid and has a magnitude of

$$F_{Re} = (29.43\ \text{kN/m})(3\ \text{m}) = 88.3\ \text{kN}$$

$$F_t = \tfrac{1}{2}(44.15\ \text{kN/m})(3\ \text{m}) = 66.2\ \text{kN}$$

Hence,

$$F_R = F_{Re} + F_t = 88.3 + 66.2 = 154.5\ \text{kN} \qquad \textit{Ans.}$$

The location of $\mathbf{F}_R$ is determined by summing moments about *B*, Fig. 9–28*b* and *c*, i.e.,

$$\circlearrowleft +(M_R)_B = \Sigma M_B;\quad (154.5)h = 88.3(1.5) + 66.2(1)$$

$$h = 1.29\ \text{m} \qquad \textit{Ans.}$$

NOTE: Using Eq. 9–14, the resultant force can be calculated as $F_R = \gamma \bar{z} A = (9810\ \text{N/m}^3)(3.5\ \text{m})(3\ \text{m})(1.5\ \text{m}) = 154.5\ \text{kN}$.