JAYDEE'S CE CLASSICAL TOURNAMENT MOCK EXAM

Rules:

1. All commented "pasali" will be registered.
2. The difficulty will be Normal, Lumberjacks, Hardcore, and Extreme.
3. Point system as follows:
   Normal : 1 pt for correct ones
   Lumberjacks: 2 pts for correct and -1 for incorrect
   Hardcore: 3 pts for correct and -2 for incorrect
   Extreme: 5 pts for correct, -3 for incorrect and -1 for no answer
4. All answers should be submitted including to the photos of your solutions to Civil Engineering Board Exam Problems – Philippines Facebook page. No solution, considered as no answer.

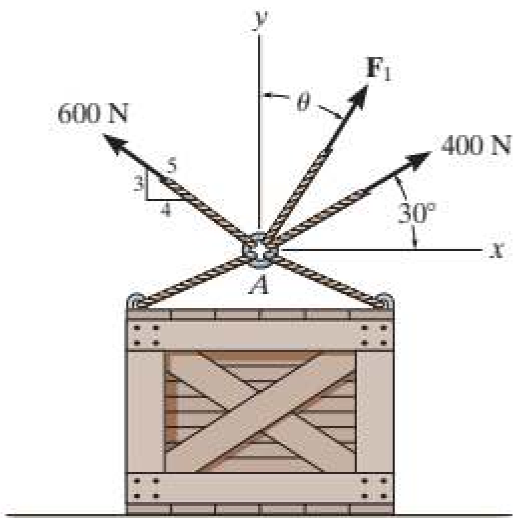
NORMAL ROUND

1. CE LAWS
   According to Republic Act 1582 , known as Civil Engineering Law , a roster showing the names and places of all businesses of all registered civil engineers shall be prepared by the Commissioner of PRC periodically but at least _____________ .

2. FLUID MECHANICS
   A crane is used to lower the weights into the sea (density = 1025 kg/m^3 for an underwater construction project. Determine the tension in the rope of the crane due to rectangular 0.4 x 0.4 x 3 m concrete block when completely immersed in water.

3. ENGINEERING MATHEMATICS (Incomplete answers are incorrect)
   Solve for x: $|3x - 5| = 7$

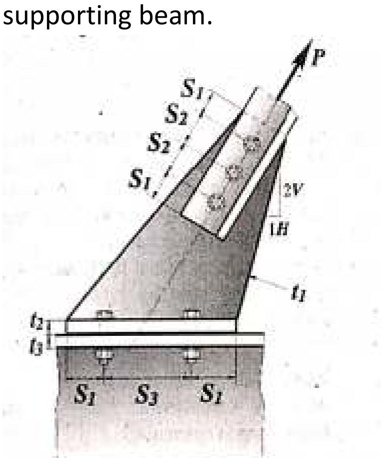
4. STRUCTURAL ENGINEERING (Incomplete answers are incorrect)
   Determine the magnitude and direction measured counterclockwise from the positive x axis of the resultant force of the three forces acting on the ring A as shown. Take F_1 = 500 N and $\theta = 20°$.



5. ENGINEERING ECONOMY
   A loan of P 5,000 is made for a period of 15 months, at a simple interest rate of 15%. What future amount is due at the end of the loan period?

LUMBERJACKS ROUND

1. STRUCTURAL STEEL
   A double angle tension member , 100 x 100 x 8 mm is subjected to a tensile load P = 210 kN. The Diagonal member is on slope 2V:H and is connected to the supporting beam by a wide tee:
   S1 = 38 mm , S2 = 75 mm , S3 = 100 , t1 t2 and t3 = 16 mm
   Allowable strength and stresses:
   Yield strength, Fy = 248 MPa , Ultimate strength Fu = 400 MPa , Bolt shear strength Ft = 150 MPa, Bolt tensile stress,Ft = 195 MPa , Bolt bearing stress = Fp = 1.2Fu
   Determine the diameter of the four bolts in tension connecting the wide tee to the flange of the supporting beam.



2. ENGINEERING MATHEMATICS
   Find the integral:

$$\int \frac{\cos^3 x}{1 - \sin x}$$

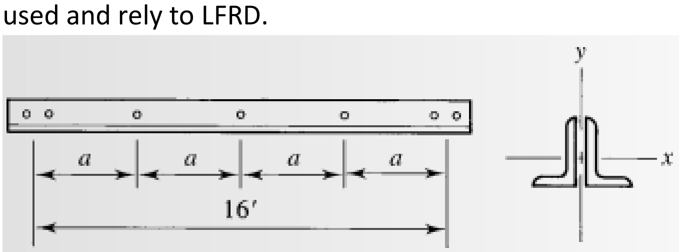
3. TRANSPORTATION ENGINEERING
   Which of the following is/are one of the types of environmental impacts of highway development?
   a. Temporary b. direct and indirect c. short and long term
   d. right of way e. cumulative

4. GEOTECHNICAL ENGINEERING
   A vane 11.25 cm long and 7.5 cm in diameter was pressed into soft clay at the bottom of a borehole. Torque was applied to cause failure of soil. The shear strength of clay was found to be 37 kPa. Determine the torque applied.

5. REINFORCED CONCRETE
   A cantilever beam 300 x 400 mm deep is 3 m long is designed with tension reinforcement only.
   Superimposed dead load = 12 kN/m
   Live load at free end = 20 kN
   Concrete unit weight = 23.5 kN/m^3
   Concrete f'c = 30 MPa
   Steel fy = 415 MPa
   Assume 70 mm concrete cover to the centroid of the tension reinforcement. Use 2001 NSCP.
   Calculate the Ultimate strength in kN m of the section if the tension reinforcement consists of 4 - 25 mmØ .

HARDCORE ROUND

1. STEEL DESIGN
   Compute the available strength of the compression member as shown in the figure. Two angles 5 x 3 x 1/2 are oriented with long legs back to back (2L5 x 3 x 2 LLBB) and separated by 3/8 inch. The effective length KL is 16 feet and there are three fully tightened intermediate connectors. A36 is used and rely to LFRD.



2. GEOMETRY
   In an acute triangle ABC, point H is the intersection of altitude CE at AB and altitude BD to AC. A circle with DE as its diameter intersects AB and AC at points F and G , respectively. FG and AH intersect at point K. If BC = 25 , BD = 20 and BE = 7 , find the length of AK.

3. HYDRAULICS
   Water enters a rotating lawn sprinkler through its base at the steady rate of 1000 ml/s as shown. The exit area of each of the two nozzles is 30 mm^2 and the flow leaving each nozzle is in the tangential direction. The radius from the axis of rotation to the centerline of each nozzle is 200 mm. Determine the speed of the sprinkler if no resisting torque is applied.

4. SURVEYING
   To determine the difference in level between two stations A and B, 4996.8 m apart, the reciprocal trigonometric levelling was performed and the readings in Table 3.15, were obtained. Assuming the mean earth's radius as 6366.20 km and the coefficient of refraction as 0.071 for both sets of observations, compute the observed value of the vertical angle of A from B and the difference in level between A and B.

Instrument at	Height of Instrument (m)	Target at	Height of Target (m)	Mean vertical angle
A	1.6	*B*	5.5	+ 1°15′32″
B	1.5	*A*	2.5	–

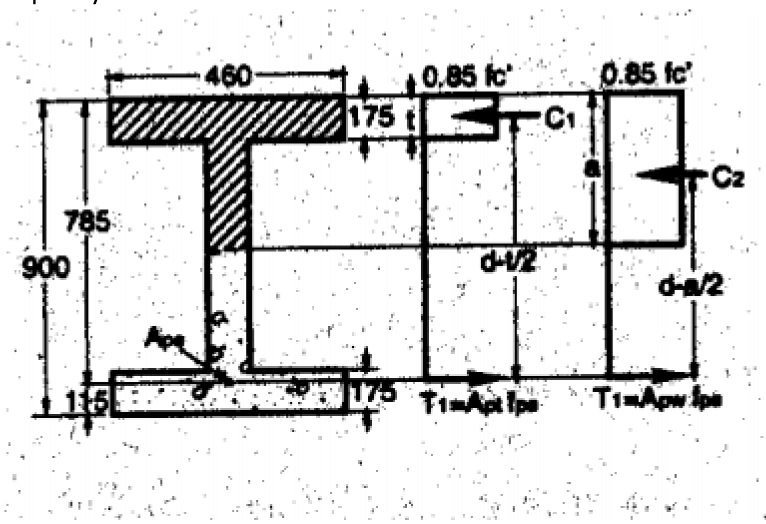
5. GEOTECHNICAL ENGINEERING
   Following are the results of the standard penetration test in sand. Determine the corrected standard penetration number at 7.5 meters.

Depth, z (m)	N_{60}
1.5	8
3.0	7
4.5	12
6.0	14
7.5	13

EXTREME ROUND

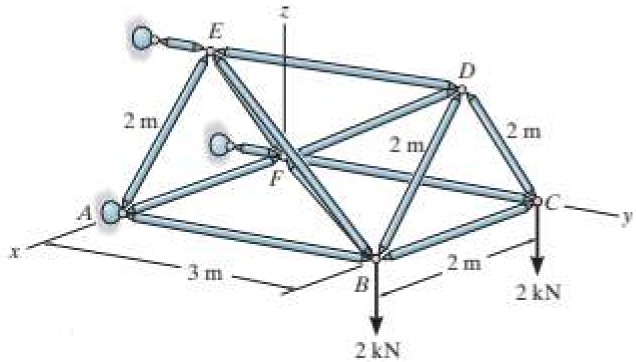
1. TRANSPORTATION ENGINEERING (Incomplete answers are incorrect)
   A 5000 lb load is places on two tires, which are then locked in place. A force of 2400 lb is necessary to cause the trailer to move at 20 mph. Determine the value of the skid number. If treaded tires were used , characterize the pavement type.

2. PRESTRESSED CONCRETE
   A prestressed I beam of one of the beams of the proposed Robinsons Galleria is prestressed with a bonded tendons having an area of Aps = 2350 mm^2 and the effective prestress after losses fse = 1100 MPa. , fpu = 1860 MPa , fc' = 48 MPa. The beam is subjected to a dead load moment of 430 kN m and live load moment of 1000 kN m. The centroid of all the prestressing steel placed at a distance of 115 mm above the bottom of the beam as shown. Determine the ultimate moment capacity.



3. FOUNDATION ENGINEERING (Careful, not all parameters is used)
   For the drilled shaft with bell given,
   Thickness of the active zone Z = 9 m
   Dead load = 1500 kN , live load = 0 , Diameter of the shaft = 1 m
   Zero swell pressure for the clay in the active zone = 600 kPa
   Average angle of plinth soil friction = 20°
   Average undrained cohesion of the clay around the bell = 150 kPa
   If an additional requirement is that the factor of safety against the uplift is at least 4 with the dead load on , what should be the diameter of the bell?

4. STRUCTURAL ANALYSIS (Incomplete answers are incorrect)
   Determine the force in members BE, DF, and BC of the space truss and state if the members are in tension or compression as shown.



5. PROBABILITY AND STATISTICS
   What is the probability that a ten digit number that is a number chosen at random between 1,000,000,000 and 9,999,999,999 inclusive will have ten different digits? Answer in 5 significant figures.

N1 Answer – Once a Year

N2 Solution © Cengel

Analysis (*a*) Consider the free-body diagram of the concrete block. The forces acting on the concrete block in air are its weight and the upward pull action (tension) by the rope. These two forces must balance each other, and thus the tension in the rope must be equal to the weight of the block:

$$V = (0.4\ \text{m})(0.4\ \text{m})(3\ \text{m}) = 0.48\ \text{m}^3$$

$$F_{T,\text{air}} = W = \rho_{\text{concrete}}\, gV$$

$$= (2300\ \text{kg/m}^3)(9.81\ \text{m/s}^2)(0.48\ \text{m}^3)\left(\frac{1\ \text{kN}}{1000\ \text{kg}\cdot\text{m/s}^2}\right) = \mathbf{10.8\ kN}$$

(*b*) When the block is immersed in water, there is the additional force of buoyancy acting upward. The force balance in this case gives

$$F_B = \rho_f gV = (1025\ \text{kg/m}^3)(9.81\ \text{m/s}^2)(0.48\ \text{m}^3)\left(\frac{1\ \text{kN}}{1000\ \text{kg}\cdot\text{m/s}^2}\right) = \mathbf{4.8\ kN}$$

$$F_{T,\text{water}} = W - F_B = 10.8 - 4.8 = \mathbf{6.0\ kN}$$

N3 Solution © Torculas

$|3x-5| = 7$.

Solution:

First rewrite $|3x-5| = 7$ without absolute value:

$$3x - 5 = 7 \quad \text{or} \quad 3x - 5 = -7$$

$$x = 4 \quad \text{or} \quad x = -2/3$$

The solution set is $\left\{-\frac{2}{3}, 4\right\}$.

N4 © Hibbeler

Scalar Notation : Suming the force components algebraically, we have

$$\xrightarrow{+} F_{R_x} = \Sigma F_x; \qquad F_{R_x} = 500\sin 20^\circ + 400\cos 30^\circ - 600\left(\frac{4}{5}\right)$$
$$= 37.42 \text{ N} \rightarrow$$

$$+\uparrow F_{R_y} = \Sigma F_y; \qquad F_{R_y} = 500\cos 20^\circ + 400\sin 30^\circ + 600\left(\frac{3}{5}\right)$$
$$= 1029.8 \text{ N} \uparrow$$

The magnitude of the resultant force $\mathbf{F}_R$ is

$$F_R = \sqrt{F_{R_x}^2 + F_{R_y}^2} = \sqrt{37.42^2 + 1029.8^2} = 1030.5 \text{ N} = 1.03 \text{ kN} \qquad \textbf{Ans}$$

The directional angle θ measured counterclockwise from positive x axis is

$$\theta = \tan^{-1}\frac{F_{R_y}}{F_{R_x}} = \tan^{-1}\left(\frac{1029.8}{37.42}\right) = 87.9^\circ \qquad \textbf{Ans}$$

N5 Solution © Tiong

$$F = P(1 + in)$$
$$F = 5000\left[1 + 0.15\left(\frac{15}{12}\right)\right]$$
$$F = 5{,}937.50$$

L1 Solution © Besavilla

$$\frac{210}{\sqrt{5}} = \frac{F_1}{2}$$
$$F_1 = 187.83 \text{ kN}$$

$$\frac{210}{\sqrt{5}} = \frac{F_h}{1}$$
$$F_h = 93.91 \text{ kN}$$

Diameter of the four bolts in tension connecting the wide tee to the flange of the supporting beam

$$F_s = \tau A_s$$
$$93910 = 150\left(\frac{\pi}{4}\right)(d^2)(4)$$
$$d = 14.12 \text{ mm}$$

Use d = ***16 mmø*** *(one of the choices)*

L2 Solution © Schaum's

$$\frac{\cos^3 x}{1-\sin x} = \frac{\cos^3 x}{1-\sin x}\cdot\frac{1+\sin x}{1+\sin x} = \frac{\cos^3 x(1+\sin x)}{\cos^2 x} = \cos x(1+\sin x) = \cos x + \cos x \sin x.$$
$$\int \frac{\cos^3 x}{1-\sin x}\,dx = \int \cos x\,dx + \int \cos x \sin x\,dx = \sin x + \tfrac{1}{2}\sin^2 x + C.$$

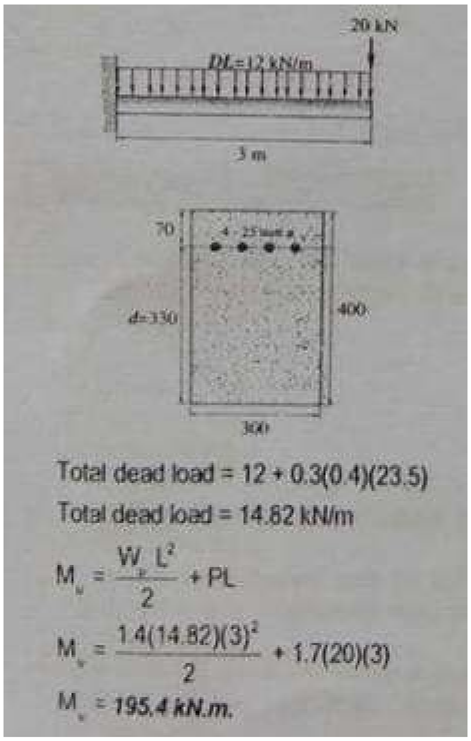
L3 Answer – BCE © Handbook of Highway Engineering

L4 Solution © Murthy

$$\text{Torque,}\quad T = c_u\,[2\pi r^2 (L + 0.67r)] \quad \text{where} \quad c_u = 37\ \text{kN/m}^2 = 3.7\ \text{N/cm}^2$$

$$= 3.7\,[2 \times 3.14 \times (3.75)^2 (11.25 + 0.67 \times 3.75)] = 4500\ \text{N-cm}$$

L5 Solution © Besavilla



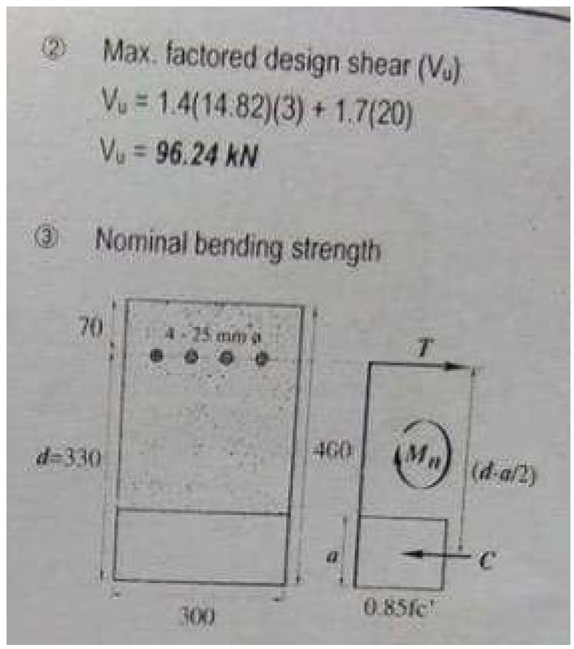
Total dead load = 12 + 0.3(0.4)(23.5)

Total dead load = 14.82 kN/m

$$M_u = \frac{W_u L^2}{2} + PL$$

$$M_u = \frac{1.4(14.82)(3)^2}{2} + 1.7(20)(3)$$

M_u = ***195.4 kN.m.***



② Max. factored design shear (V_u)

$V_u = 1.4(14.82)(3) + 1.7(20)$

V_u = ***96.24 kN***

③ Nominal bending strength

$$T = A_s f_y$$

$$T = \frac{\pi}{4}(25)^2(4)(415)$$

$$T = 814{,}850 \text{ N.mm}$$

$$C = T$$

$$0.85 f_c' ab = A_s f_y$$

$$0.85(30)(a)(300) = 814{,}850$$

$$a = 106.52 \text{ mm}$$

$$M_n = T\left(d - \frac{a}{2}\right)$$

$$M_n = 814850\left(330 - \frac{106.52}{2}\right)$$

$$M_n = \boldsymbol{225.5 \text{ kN.m.}}$$

Mu = 0.9(225.5) = 202.95 kN m

H1 Solution © Segui

$$\frac{K_x L}{r_x} = \frac{16(12)}{1.58} = 121.5$$

$$F_e = \frac{\pi^2 E}{(KL/r)^2} = \frac{\pi^2(29{,}000)}{(121.5)^2} = 19.39 \text{ ksi}$$

$$4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29{,}000}{36}} = 134$$

Since $\dfrac{KL}{r} < 4.71\sqrt{\dfrac{E}{F_y}}$, use AISC Equation E3-2.

$$F_{cr} = 0.658^{(F_y/F_e)} F_y = 0.658^{(36/19.39)}(36) = 16.55 \text{ ksi}$$

The nominal strength is

$$P_n = F_{cr} A_g = 16.55(7.50) = 124.1 \text{ kips}$$

To determine the flexural-torsional buckling strength for the y-axis, use the modified slenderness ratio, which is based on the spacing of the connectors. The unmodified slenderness ratio is

$$\left(\frac{KL}{r}\right)_0 = \frac{KL}{r_y} = \frac{16(12)}{1.24} = 154.8$$

The spacing of the connectors is

$$a = \frac{16(12)}{4 \text{ spaces}} = 48 \text{ in.}$$

Then, from Equation 4.14,

$$\frac{Ka}{r_i} = \frac{Ka}{r_z} = \frac{48}{0.642} = 74.77 < 0.75(154.8) = 116.1 \quad \text{(OK)}$$

$$\frac{Ka}{r_i} = \frac{Ka}{r_z} = \frac{48}{0.642} = 74.77 < 0.75(154.8) = 116.1 \quad \text{(OK)}$$

Compute the modified slenderness ratio, $(KL/r)_m$:

$$\frac{a}{r_i} = \frac{48}{0.642} = 74.77 > 40 \qquad \therefore \text{Use AISC Equation E6-2b}$$

$$\frac{K_i a}{r_i} = \frac{0.5(48)}{0.642} = 37.38$$

$$\left(\frac{KL}{r}\right)_m = \sqrt{\left(\frac{KL}{r}\right)_o^2 + \left(\frac{K_i a}{r_i}\right)^2} = \sqrt{\left((154.8)^2 + (37.38)^2\right)} = 159.2$$

This value should be used in place of KL/r_y for the computation of F_{cry}:

$$F_e = \frac{\pi^2 E}{(KL/r)^2} = \frac{\pi^2(29{,}000)}{(159.2)^2} = 11.29 \text{ ksi}$$

Since $\dfrac{KL}{r} > 4.71\sqrt{\dfrac{E}{F_y}} = 134$,

$$F_{cry} = 0.877F_e = 0.877(11.29) = 9.901 \text{ ksi}$$

From AISC Equation E4-3,

$$F_{crz} = \frac{GJ}{A_g \bar{r}_o^2} = \frac{11{,}200(2 \times 0.322)}{7.50(2.51)^2} = 152.6 \text{ ksi}$$

$$F_{cry} + F_{crz} = 9.901 + 152.6 = 162.5 \text{ ksi}$$

$$F_{cr} = \left(\frac{F_{cry} + F_{crz}}{2H}\right)\left[1 - \sqrt{1 - \frac{4F_{cry}F_{crz}H}{(F_{cry} + F_{crz})^2}}\right]$$

$$= \frac{162.5}{2(0.646)}\left[1 - \sqrt{1 - \frac{4(9.832)(152.6)(0.646)}{(162.5)^2}}\right] = 9.599 \text{ ksi}$$

The nominal strength is

$$P_n = F_{cr}A_g = 9.599(7.50) = 71.99 \text{ kips}$$

Therefore the flexural-torsional buckling strength controls.

The design strength is

$$\phi_c P_n = 0.90(71.99) = 64.8 \text{ kips}$$

H2 Solution © Hainan Olympiad

Solution We know that $\angle ADB = \angle AEC = 90°$, therefore

$$\triangle ADB \backsim \triangle AEC,$$

and

$$\frac{AD}{AE} = \frac{BD}{CE} = \frac{AB}{AC}. \qquad (1)$$

But $BC = 25$, $BD = 20$, and $BE = 7$, so $CD = 15$, and $CE = 24$. From (1), we obtain

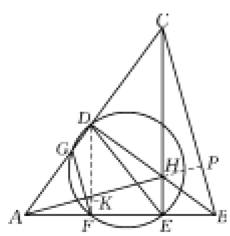
$$\begin{cases} \dfrac{AD}{AE} = \dfrac{5}{6}, \\ \dfrac{AE + 7}{AD + 15} = \dfrac{5}{6}, \end{cases}$$

and the solution is

$$\begin{cases} AD = 15, \\ AE = 18. \end{cases}$$

Thus, point D is the midpoint of the hypotenuse AC of Rt$\triangle AEC$, and

$$DE = \frac{1}{2}AC = 15.$$



Draw line DF. Since point F is on the circle with DE as its diameter, $\angle DFE = 90^\circ$, we have

$$AF = \frac{1}{2}AE = 9.$$

Since four points G, F, E and D are concyclic, and four points D, E, B and C are concyclic too, we get

$$\angle AFG = \angle ADE = \angle ABC.$$

Thus $GF \parallel CB$. Extend line AH to intersect BC at point P, then

$$\frac{AK}{AP} = \frac{AF}{AB}. \qquad (2)$$

Since H is the orthocenter of $\triangle ABC$, $AP \perp BC$. From $BA = BC$ we have

$$AP = CE = 24.$$

Due to (2), we get

$$AK = \frac{AF \cdot AP}{AB} = \frac{9 \times 24}{25} = 8.64.$$

H3 Solution © Munson

To solve parts **(a)**, **(b)**, and **(c)** of this example we can use the same fixed and nondeforming, disk-shaped control volume illustrated in Fig. 5.4. As indicated in Fig. E5.18*a*, the only axial torque considered is the one resisting motion, T_{shaft}.

(a) When the sprinkler head is held stationary as specified in part **(a)** of this example problem, the velocities of the fluid entering and leaving the control volume are shown in Fig. E5.18*b*. Equation 5.46 applies to the contents of this control volume. Thus,

$$T_{\text{shaft}} = -r_2 V_{\theta 2}\dot{m} \qquad \textbf{(1)}$$

Since the control volume is fixed and nondeforming and the flow exiting from each nozzle is tangential,

$$V_{\theta 2} = V_2 \qquad \textbf{(2)}$$

Equations 1 and 2 give

$$T_{\text{shaft}} = -r_2 V_2 \dot{m} \qquad \textbf{(3)}$$

In Example 5.7, we ascertained that $V_2 = 16.7$ m/s. Thus, from Eq. 3 with

$$\dot{m} = Q\rho = \frac{(1000\ \text{ml/s})(10^{-3}\ \text{m}^3/\text{liter})(999\ \text{kg/m}^3)}{(1000\ \text{ml/liter})}$$
$$= 0.999\ \text{kg/s}$$

we obtain

$$T_{\text{shaft}} = -\frac{(200\ \text{mm})(16.7\ \text{m/s})(0.999\ \text{kg/s})[1\ (\text{N/kg})/(\text{m/s}^2)]}{(1000\ \text{mm/m})}$$

or

$$T_{\text{shaft}} = -3.34\ \text{N}\cdot\text{m} \qquad \text{(Ans)}$$

(b) When the sprinkler is rotating at a constant speed of 500 rpm, the flow field in the control volume is unsteady but cyclical. Thus, the flow field is steady in the mean. The velocities of the flow entering and leaving the control volume are as indicated in Fig. E5.18*c*. The absolute velocity of the fluid leaving each nozzle, V_2, is from Eq. 5.43,

$$V_2 = W_2 - U_2 \tag{4}$$

where

$$W_2 = 16.7 \text{ m/s}$$

as determined in Example 5.7. The speed of the nozzle, U_2, is obtained from

$$U_2 = r_2\omega \tag{5}$$

Application of the axial component of the moment-of-momentum equation (Eq. 5.46) leads again to Eq. 3. From Eqs. 4 and 5,

$$\begin{aligned} V_2 &= 16.7 \text{ m/s} - r_2\omega \\ &= 16.7 \text{ m/s} - \frac{(200 \text{ mm})(500 \text{ rev/min})(2\pi \text{ rad/rev})}{(1000 \text{ mm/m})(60 \text{ s/min})} \end{aligned}$$

or

$$V_2 = 16.7 \text{ m/s} - 10.5 \text{ m/s} = 6.2 \text{ m/s}$$

Thus, using Eq. 3, with $\dot{m} = 0.999$ kg/s (as calculated previously), we get

$$T_{\text{shaft}} = -\frac{(200 \text{ mm})(6.2 \text{ m/s})\, 0.999 \text{ kg/s}\, [1 \text{ (N/kg)}/(\text{m/s}^2)]}{(1000 \text{ mm/m})}$$

or

$$T_{\text{shaft}} = -1.24 \text{ N} \cdot \text{m} \qquad \text{(Ans)}$$

(c) When no resisting torque is applied to the rotating sprinkler head, a maximum constant speed of rotation will occur as demonstrated below. Application of Eqs. 3, 4, and 5 to the contents of the control volume results in

$$T_{\text{shaft}} = -r_2(W_2 - r_2\omega)\dot{m} \tag{6}$$

For no resisting torque, Eq. 6 yields

$$0 = -r_2(W_2 - r_2\omega)\dot{m}$$

Thus,

$$\omega = \frac{W_2}{r_2} \tag{7}$$

In Example 5.4, we learned that the relative velocity of the fluid leaving each nozzle, W_2, is the same regardless of the speed of rotation of the sprinkler head, ω, as long as the mass flowrate of the fluid, $\dot{m}$, remains constant. Thus, by using Eq. 7 we obtain

$$\omega = \frac{W_2}{r_2} = \frac{(16.7 \text{ m/s})(1000 \text{ mm/m})}{(200 \text{ mm})} = 83.5 \text{ rad/s}$$

or

$$\omega = \frac{(83.5 \text{ rad/s})(60 \text{ s/min})}{2\,\pi \text{ rad/rev}} = 797 \text{ rpm} \qquad \text{(Ans)}$$

H4 Solution © Chandra

Solution (Fig. 3.9):

Height of instrument at A, $h_i = 1.6$ m

Height of target at B, $h_S = 5.5$ m

Correction for eye and object to the angle α' observed from A to B

$$\begin{aligned} \varepsilon_A &= \frac{h_S - h_i}{d}.206265 \text{ seconds} \\ &= \frac{5.5 - 1.6}{4996.8} \times 206265 \text{ seconds} \\ &= 2'41'' \end{aligned}$$

Similarly, the correction for eye and object to the angle β' observed from B to A

$$\varepsilon_B = \frac{2.5 - 1.5}{4996.8} \times 206265 \text{ seconds} = 41.3''$$

Length of arc at mean sea level subtending an angle of 1″ at the centre of earth

$$= \frac{R \times 1''}{206265} \times 1000$$

$$= \frac{6366.2 \times 1''}{206265} \times 1000 = 30.86 \text{ m}$$

Therefore angle θ subtended at the centre of earth by AB

$$= \frac{4996.8}{30.86}$$

$$\theta = 2'41.9''$$

Refraction $\upsilon = K\theta$

$$= 0.071 \times 2'41.9'' = 11.5''$$

Therefore correction for curvature and refraction

$$\theta/2 - \upsilon = \frac{2'41.5''}{2} - 11.5'' = 1'9.5''$$

Corrected angle of elevation for eye and object

$$\alpha = \alpha' - \varepsilon_A$$

$$= 1°15'32'' - 2'41'' = 1°12'51''$$

Corrected angle of elevation for curvature and refraction

$$\alpha + \theta/2 - \upsilon = 1°12'51'' + 1'9.5''$$

$$= 1°14'0.5''$$

If b is the angle of depression at B corrected for eye and object then

$$\alpha + \theta/2 - \upsilon = \beta - (\theta/2 - \upsilon)$$

or $\beta = 1°14'0.5'' + 1'9.5'' = 1°15'10''$

If the observed angle of depression is β' then

$$\beta' - \beta' - \varepsilon_B$$

or $\beta' = \beta + \varepsilon_B$

$$= 1°15'10'' + 41.3'' = \mathbf{1°15'51.3''}$$

Now the difference in level

$$\Delta h = AC \tan\left(\frac{\alpha' + \beta'}{2}\right)$$

$$= 4996.8 \times \tan\left(\frac{1°12'51'' + 1°15'51.3''}{2}\right)$$

$$= \mathbf{108.1 \text{ m}}$$

H5 Solution © Das

$$C_N = \left[\frac{1}{\left(\frac{\sigma'_o}{p_a}\right)}\right]^{0.5}$$

$$p_a \approx 100\ \text{kN/m}^2$$

Depth, z (m)	σ'_o (kN/m²)	C_N	N_{60}	$(N_1)_{60}$
1.5	25.95	1.96	8	≈16
3.0	51.90	1.39	7	≈10
4.5	77.85	1.13	12	≈14
6.0	103.80	0.98	14	≈14
7.5	129.75	0.87	13	≈11

E1 Solution © Hoel

First, calculate the skid number using Equations 22.2 and 22.3,

SK = 100 * (L / N)

SK = 100 * (2400 / 5000) = 48

Therefore, the skid number would be 48. Based on the skid number determined above and Figure 22.14, the pavement can be characterized as having a surface type (3), fine-textured and gritty.

E2 Solution © Besavilla

Solution:

$Pp = \frac{Aps}{bd}$

$Pp = \frac{2350}{(460)(785)}$

$Pp = 0.00651$

$fp_s = fpu\left[1 - \frac{0.5\ Pp\ fpu}{fc'}\right]$

$fp_s = 1860\left[1 - \frac{0.5\ (.00651)\ (1860)}{48}\right]$

$fp_s = 1625$ MPa.

$T = Ap_s\ fp_s$

$T = 2350\ (1625)$

$T = 3818750$

$C = T$

$.85\ fc'\left[460(175) + (a-175)(140)\right] = 3818750$

$0.85\ (48)\left[460\ (175) + (a - 175)\ (140)\right] = 3818750$

$3284400 + 5712\ a - 999600 = 3818750$

$a = 268.55$ mm.

$C_1 = T$

$0.85\ fc'\ (460-140)(175) = Ap\ fps$

$0.85\ (48)\ (320)\ (175) = Ap\ f\ (1625)$

$Ap\ f = 1406\ mm^2$

$Apf + Apw = Aps$

$Ap_w = 2350 - 1406$

$Ap_w = 944\ mm^2$.

$$M_1 = \text{ø}\,T_1\left(d - \frac{t}{2}\right)$$

$$M_1 = 0.90\ Apf\ fps\left(d - \frac{t}{2}\right)$$

$$M_1 = 0.90(1406)(1625)\left(785 - \frac{175}{2}\right)$$

$$M_1 = 1434 \times 10^6$$

$$Pp_w = \frac{Pp_w}{b_w\,d}$$

$$Pp_w = \frac{944}{140\ (785)}$$

$$Pp_w = 0.00859$$

$$w_{pw} = \frac{w_{pw}\,f_{ps}}{fc'}$$

$$w_{pw} = \frac{0.00859\ (1625)}{48}$$

$$w_{pw} = 0.29 < 0.30$$

$$M_2 = \text{ø}\,T_2\left(d - \frac{a}{2}\right)$$

$$M_2 = 0.90\ Apw\ fpw\left(d - \frac{a}{2}\right)$$

$$M_2 = 0.90\ (944)(1625)\left(785 - \frac{268.55}{2}\right)$$

$$M_2 = 898 \times 10^6$$

$$Mu = M_1 + M_2$$

$$Mu = (1434 + 898) \times 10^6$$

$Mu = 2332 \times 10^6$ (ultimate moment capacity)

E3 Solution © Das

Eq. (13.14): $U = \pi D_s Z \sigma'_i \tan\phi'_{ps}$

$D_s = 1$ m; $Z = 9$ m

$U = (\pi)(1)(9)(600)(\tan 20) = 6174.6$ kN

Eq. (13.17): $U = \dfrac{c_u N_c}{\text{FS}}\,\dfrac{\pi}{4}\left(D_b^2 - D_s^2\right)$

$$6174.6 = \left(\frac{(150)(6.14)}{3}\right)\left(\frac{\pi}{4}\right)\left(D_b^2 - 1^2\right) = 241.1\left(D_b^2 - 1\right)$$

or $25.61 + 1 = D_b^2$

$D_b = \mathbf{5.16\ m}$

$$\text{FS} = \frac{(c_u N_c)\left(\frac{\pi}{4}\right)(D_b - D_s^2)}{U - D}$$

$$4 = \frac{(150)(6.14)\left(\frac{\pi}{4}\right)(D_b^2 - 1^2)}{6174.6 - 1500} = \frac{723.35\left(D_b^2 - 1\right)}{4674.6}$$

or $25.85 = D_b^2 - 1$

$D_b = \mathbf{5.2\ m}$

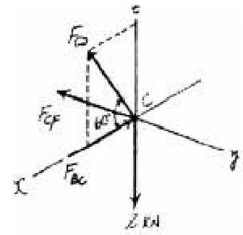
E4 Solution © Hibbeler

Joint *C*:

$\sum F_z = 0;\qquad F_{CD}\sin 60^\circ - 2 = 0 \qquad F_{CD} = 2.309\text{ kN (T)}$

$\sum F_x = 0;\qquad 2.309\cos 60^\circ - F_{BC} = 0$

$F_{BC} = 1.154\text{ kN (C)} = 1.15\text{ kN (C)}$ **Ans.**



Joint *D*: Since F_{CD}, F_{DE} and F_{DF} lie within the same plane and F_{DE} is out of this plane, then $F_{DE} = 0$.

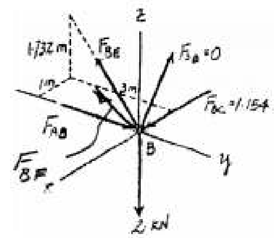
$\sum F_x = 0;\qquad F_{DF}\left(\frac{1}{\sqrt{13}}\right) - 2.309\cos 60^\circ = 0$

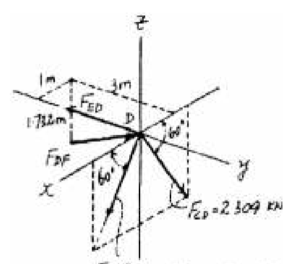
$F_{DF} = 4.16\text{ kN (C)}$ **Ans.**

Joint *B*:

$\sum F_z = 0;\qquad F_{BE}\left(\frac{1.732}{\sqrt{13}}\right) - 2 = 0$

$F_{BE} = 4.16\text{ kN (T)}$ **Ans.**





E5 Solution: © Wells

417. From the numbers given it is clear that the number chosen cannot start with a 0. The number of allowable pandigital numbers is therefore the total number, including initial zero, less the number starting with a zero: it is 10! − 9! = 9 × 9!

There are 9,000,000,000 numbers in the range, so the probability is (9 × 9!)/(9 × 10⁹) = 362,880/1,000,000,000 = 0.00036288, or less than 1 in 2500.