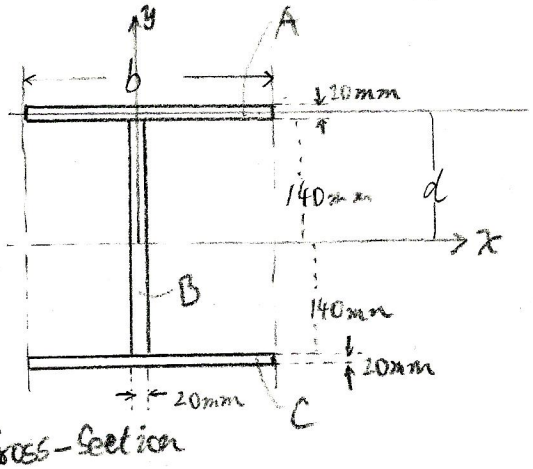
4.



Cross-Section

Final Exam 2007 4.

note: 这种题公式比较多，容易出错。一定要先写出公式再代入数字。
单位全统一到 kPa, kN, m, m^4

Rectangle A:

$$I_x = \bar{I}_x + Ad^2$$

合理使用科学记数法来简化计算.

$$I_x = \frac{1}{12} \times b \times (20\times10^{-3})^3 + 20\times10^{-3} \times b \times 0.150^2$$
$$= 666.66\, b \times 10^{-9} + 0.45b \times 10^{-3} \quad m^4$$

Rectangle B:

$$I_x = \frac{1}{12} \times 20\times10^{-3} \times 0.28^3 = 3.658 \times 10^{-5}\, m^4$$

Rectangle C:

Same as Rectangle A.

$\therefore I$ = Rectangle A × 2 + Rectangle B

$$= 1333.336 \times 10^{-9} + 0.96 \times 10^{-3} + 3.658 \times 10^{-5}$$
$$= 0.133333b \times 10^{-5} + 906 \times 10^{-5} + 3.658 \times 10^{-5}$$
$$= 90.133333 \times 10^{-5} + 3.658 \times 10^{-5}$$

$$\sigma = \frac{M \cdot y}{I} = \frac{F}{A}$$

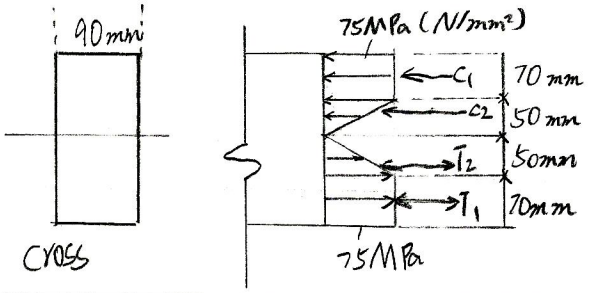
容许应力 = 破坏强度 / 安全系数

$$\frac{360000\ kPa}{1.8} = \frac{334.5\ kN \times 0.16\ m}{90.13333\, b\ m^4 \times 10^{-5} + 3.658 \times 10^{-5}\ m^4}$$

$$90.133b = 21.693$$
$$b = 0.2406\ m$$
$$\approx 240.6\ mm$$

$\therefore$ 250mm is required.

b A beam with a rectangular cross-section is subjected to a bending moment M which produces the stresses shown in side view. Determine the bending moment M.



$C_1 = \frac{75 \times 70 \times 90}{\text{MPa}\ (N/mm^2)\quad mm^2} = 472.5\,kN$ 单位问题

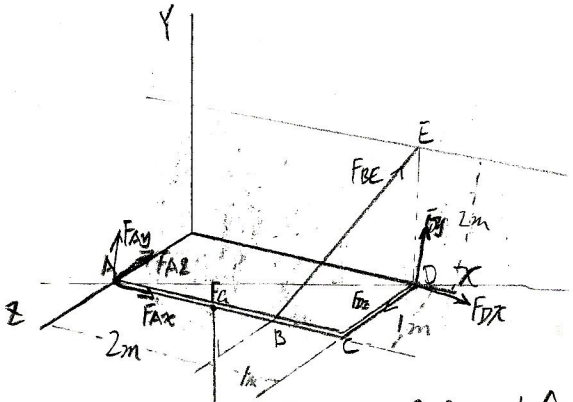
$C_2 = \frac{75 \times 50 \times 90}{2} = 168.75\,kN$

$EM = 472.5\,kN \cdot 0.17\,m + 168.75\,kN \times 66.6 \times 10^{-3}\,m$

$= 80.352\,kN \cdot m + 11.2\,kN \cdot m$

$= 91.5\,kN \cdot m$

3. An L-shaped pipe bracket is supported by a ball-and socket at A, by a ball-and socket at D which has been modified to permit movement in the z direction, and by cable BE. The mass of the pipe segment AC is 2 kg/m whereas the mass of segment CD can be neglected. Determine the tension in cable BE and the components of the reaction at D.



Points
A(0, 0, 1)
B(2, 0, 1)
C(3, 0, 1)
D(3, 0, 0)
E(3, 2, 0)
F_G(1.5, 0, 1)

$G = 2 \times 3 \times 9.8 = 58.8N$

$F = 58.8j$

$\Sigma M_{AD} = \begin{vmatrix} \frac{3}{\sqrt{10}} & 0 & \frac{-1}{\sqrt{10}} \\ 1.5 & 0 & 0 \\ 0 & 58.8 & 0 \end{vmatrix} + \begin{vmatrix} \frac{3}{\sqrt{10}} & 0 & \frac{-1}{\sqrt{10}} \\ 0 & 2 & 0 \\ \frac{1}{\sqrt{6}}T_{BE} & \frac{2}{\sqrt{6}}T_{BE} & \frac{-1}{\sqrt{6}}T_{BE} \end{vmatrix} = 0$ 代数和！主由坐标确定.

$= -\left[\frac{1}{\sqrt{10}} \times 1.5 \times 58.8\right] + \left[\frac{3}{\sqrt{10}}\left(2 \times \frac{-1}{\sqrt{6}}T_{BE}\right) + \frac{1}{\sqrt{10}}\left(-2 \times \frac{1}{\sqrt{6}}T_{BE}\right)\right]$

$= -27.89 + [-0.77 T_{BE} + 0.25 T_{BE}]$

$T_{BE} = 54.01N$ Ans.

$V_{AD}(3i, 0j, -1k)$
$u_{AD} = \frac{3}{\sqrt{10}}i - \frac{1}{\sqrt{10}}k$ } 用AD轴算M

$V_{BE}(1i, 2j, -1k)$
$u_{BE} = \frac{1}{\sqrt{6}}i + \frac{2}{\sqrt{6}}j + \frac{-1}{\sqrt{6}}k$

$T_{BE} = u_{BE} \times T_{BE}$ (可得i,j,k分量)

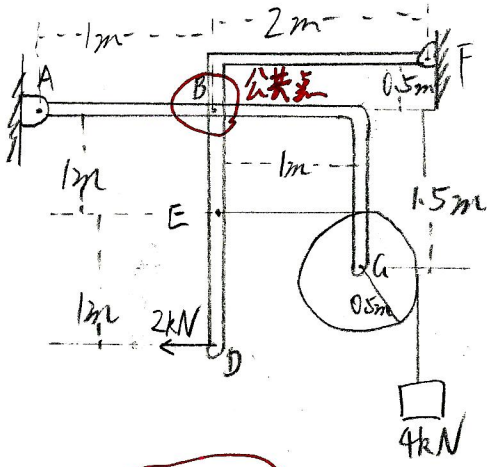
$V_{AF}(1.5i, 0j, 0k)$
$V_{DE}(0i, 2j, 0k)$ } 力臂

$V_{AF}(1.5i, 0j, 0k)$ $V_{AB}(2, 0, 0)$ $V_{AD}(3, 0, -1)$

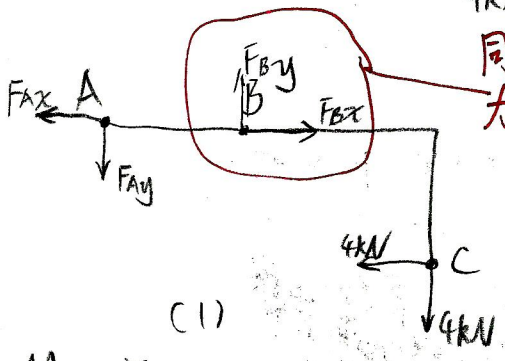
4. The pulley on the pin-connected frame has a radius of 0.5m.

(a) Determine the components of the forces at the three pins on member ABC. Show your answers on a separate the sketch of ABC.

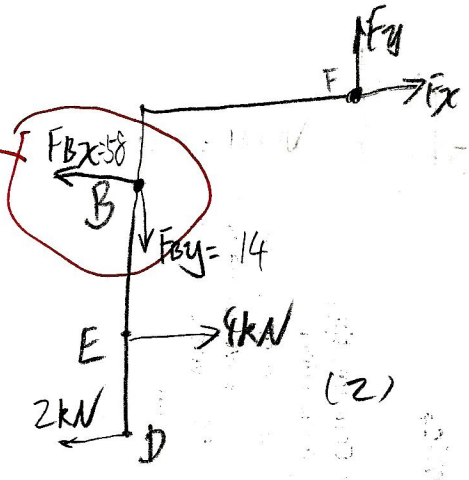
(b) Determine the reaction components at F.



note：拆分元件，每个元件自身还是平衡的，公共点作为各系统(元件)之间的桥梁，可用来连立方程组或传递参数.



同一Pin上两个元件力反向(内力)



(1)

$\sum M_A = -F_{By} \times 1 + 4 \times 1.5 + 4 \times 2$

$\Rightarrow F_{By} = 14\ kN$ (1)

$\sum M_F = 2 \times 2.5 - 4 \times 1.5 - F_{By} \times 2 + F_{Bx} \times 0.5 = 0$

$F_{Bx} = 58\ kN$ (2)

(1)

$\sum F_y = 0 = F_{Ay} + 14 - 4 \Rightarrow F_{Ay} = 10\ kN$

$\sum F_x = 0 = F_{Ax} - F_{Bx} + 4kN \Rightarrow F_{Ax} = 54\ kN$

(2)

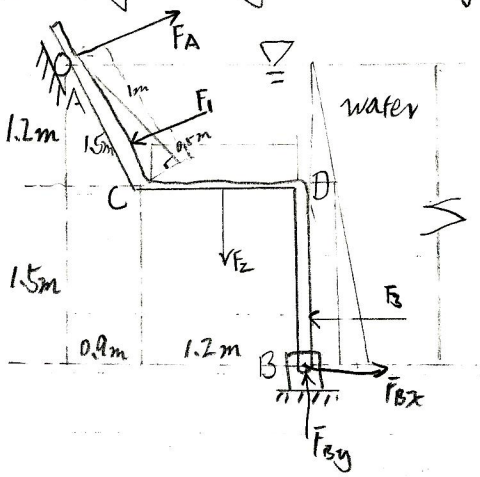
$\sum F_y = 0 = F_y - F_{By} = 0 \Rightarrow F_y = 10\ kN$

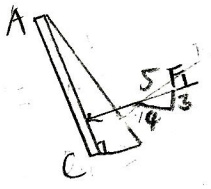
$\sum F_x = 0 = 58 + 2 - 4 - F_x \Rightarrow F_x = 56\ kN$

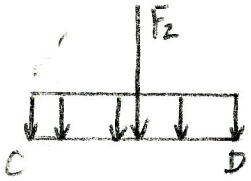
1. Water problem CIV 100

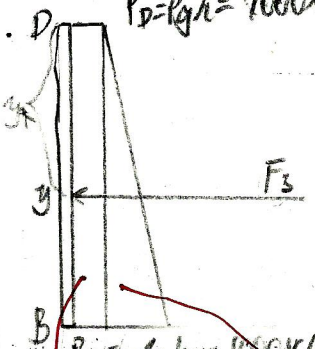
AB represents the cross section of a 3m wide dam that has fresh water of depth 2.7m on one side. Neglecting the weight of the dam calculate the reactions at A and B.

这种题要注意 wide，不能直接看成平面来算









$P_D = \rho g h = 1000 \times 9.8 \times 1.2 = 11760 N/m^2$

For seg AC.

$P_{AC} = \rho g h = 1000 \times 9.8 \times 1.2 = 11760 N/m^2$

$F_1 = \frac{1}{2} \times 11760 \times 1.5 \times 3 = 26460 N$

$F_{1x} = \frac{4}{5} \times 26460 = 21186 N$

$F_{1y} = \frac{3}{5} \times 26460 = 15876 N$

For seg CD:

$P_{CD} = \rho g h = 1000 \times 9.8 \times 1.2 = 11760 N/m^2$

$F_2 = 11760 \times 1.2 \times 3 = 42336 N$

$P_B = \rho g h = 1000 \times 9.8 \times 2.7 = 26460 N/m^2$

$F_3 = \frac{1}{2} \times 11760 \times 1.5 \times 3 + \frac{1}{2} \times 14700 \times 1.5 \times 3$

$= 85995 N$

$85995 \times y_* = \frac{1}{2} \times 11760 \times 1.5 \times 0.75 + \frac{1}{2} \times 14700 \times 1.5 \times 1$

$y_* = \frac{72765}{85995} = 0.84 m$

Moment 用来计算 y_*

$\sum M_B = F_A \times 3.42 - F_{1x} \times 1.9 - F_{1y} \times 1.5 - F_2 \times 0.6 - F_3 \times 0.66 = 0$

$F_A = \frac{21186 \times 1.9 + 15876 \times 1.5 + 42336 \times 0.6 + 85995 \times 0.66}{3.42} = 42756 N$

$F_{Ax} = 42756 \times \frac{4}{5} = 34204.8 N$

$F_{Ay} = 42756 \times \frac{3}{5} = 25653.6 N$

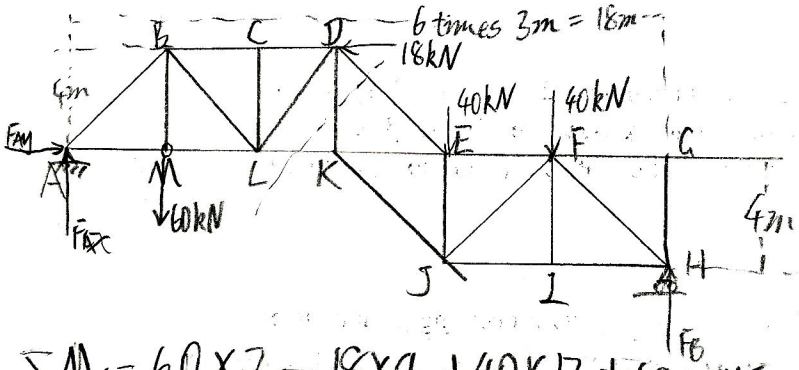
$\sum F_y = 0 = 25653.3 - 15876 - 42336 + F_{By}$

$F_{By} = 32558.4 N$

$\sum F_x = 0 = 34204.8 - 21186 - 26460 + F_{Bx}$

$F_{Bx} = 72976.2 N$

5. For the given truss shown supported by a pin at A and a roller at H, 钢梁
(a) determine the forces in members EJ, LK and IF,
(b) determine the cross section of member LK if the failure stress for the material is 100MPa and the load (safety) factor is 1.8. Assume a square cross section,
(c) calculate the elongation of member BM. The modulus of elasticity E, of the material is 200000MPa.



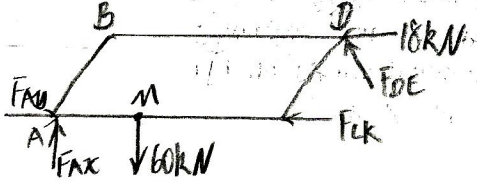
$\Sigma M_A = 60\times3 - 18\times4 + 40\times12 + 40\times15 - F_B\times18$

$F_B = 66kN$

$\Sigma F_y = 0 = F_{AY} - 60 - 40 - 40 + 66 = 0$

$F_{AY} = 74kN$

$F_{AX} = 18kN$



$\Sigma M_D = -F_{AY}\times4 + F_{AX}\times9 - 60\times6 + F_{LK}\times4 = 0$

$= -18\times4 + 74\times9 - 60\times6 + F_{LK}\times4 = 0$

$F_{LK} = 58.5\ kN$

未知力多于平衡方程时候不能随意设力的方向. 要考虑实际情况.

$\Sigma M_F = F_{KJ}\times4.24 - F_{EJ}\times3 - F_B\times3 = 0 \Rightarrow F_{KJ}\times4.24 - 3F_{EJ} - 198 = 0$ (1)

$\Sigma F_y = \frac{3}{4.24}F_{KJ} - F_{EJ} - 40 + F_B = 0$

$\Rightarrow 2.12F_{KJ} - 3F_{EJ} + 78 = 0$ (2)

(1)-(2): $2.12F_{KJ} - 276 = 0$

$F_{KJ} = 130.18kN$

$\Rightarrow F_{EJ} = 118.04kN$

$F_{IF} = 0$ (Zero force member) (1)

(b)

$\sigma = \frac{F}{A} = \frac{M\cdot y_{max}}{I}$ key

$\frac{100000}{1.8} = \frac{F_{LK}}{b^2}$

$b = \sqrt{b^2} = \sqrt{\frac{58.5}{55555.5}} = 0.0324m$

BM本身是0杆 (1) $= 32.4mm$

(c) key

$\Delta L = FL/EA$ L杆长 A截面面积

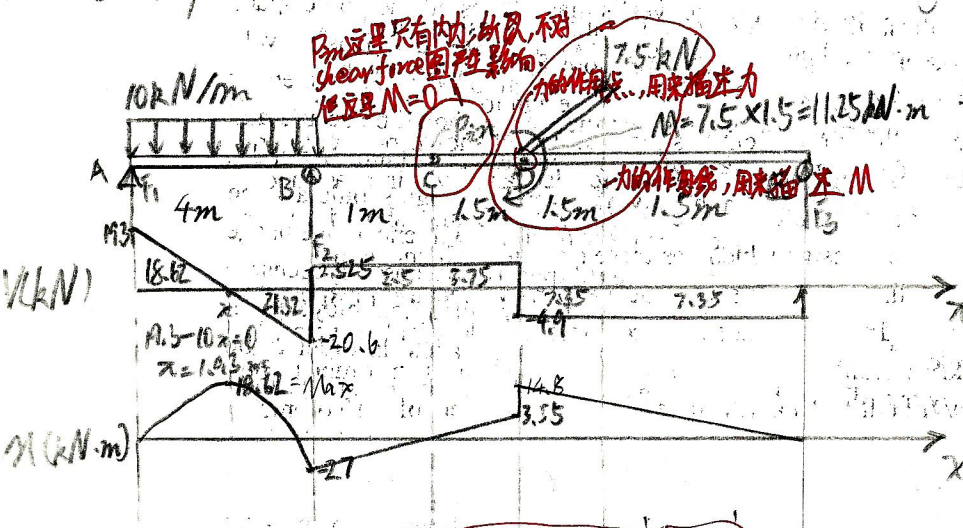
$\Delta L = \frac{60\times3}{200000000\times0.032^2} = \frac{180}{20480}$

$= 0.008m = 8mm$

零杆判断方法:
(1) 一节点上有三根杆件,如果节点上无外力的作用,其中两根共线,则另一杆为零杆.
(2) 一节点上只有二根不共线杆件,如果节点上无外力的作用,则两根杆件均为零杆.
(3) 一节点上只有两根不共线杆件,如果作用在节点上的外力沿其中一杆,则另一杆为零杆.

2. shear force CIV 100

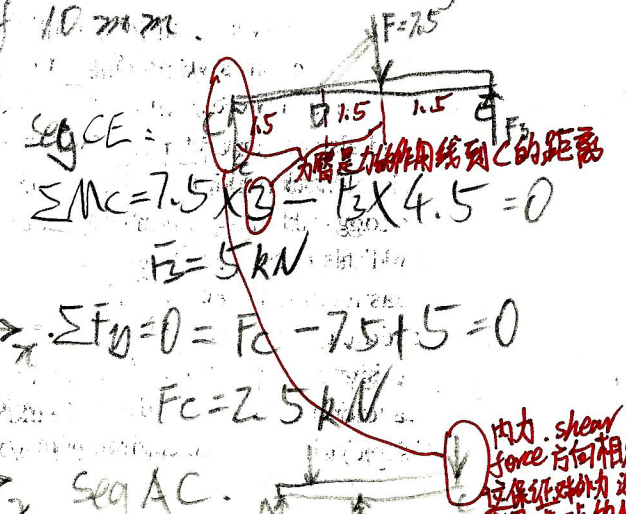
In the space provide plot the shear force and bending moment diagrams for the Wood beam ABCDE and show all key values. The failure stress for the material in compression and tension is 8 MPa and the load (safe) factor is 1.9 Determine the required depth d for the rectangular cross section of the beam shown. Depth are available in increments of 10 mm.



C点这里只有内力，故风不对 shear force图产生影响；但应是M=0

7.5 kN 力的作用点，用来画走力

$M = 7.5 \times 1.5 = 11.25\ kN \cdot m$ 一力的作用线，用来描述 M



$\sigma = \frac{My}{I}$ y到形心的距离

I：C方形的bh化 $I = \frac{1}{12}bh^3$ 整个方形的高！

$8\ MPa = 8000\ kPa$

$M = 78.62\ kN \cdot m$ 单位统一

$I = \frac{1}{12} \times 0.15\ m \times d^3$

$\therefore \sigma = \frac{8000}{1.9} = \frac{18.62 \times \frac{1}{2}d}{\frac{1}{12} \times 0.15 \times d^3 \times 2}$

破坏强度 / 安全系数

容许应力 = 破坏强度 / 安全系数

$4210.5 = \frac{9.31}{\frac{1}{12} \times 0.15\ d^2}$

$52.63\ d^2 = 9.31$

$d^2 = 0.176$

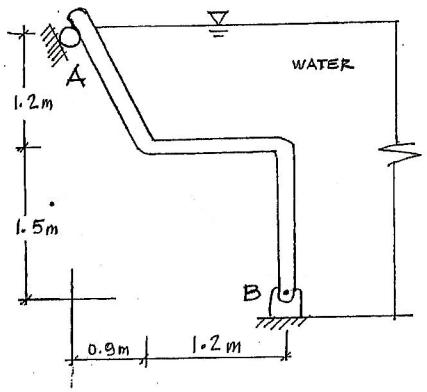
$d = 0.4195\ m = 420\ mm$

CIV 100 MECHANICS – FINAL EXAM 2008

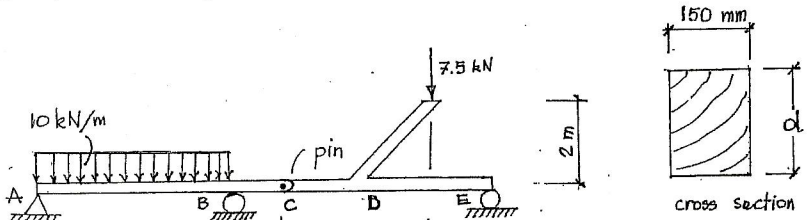
1. **AB** represents the cross section of a 3 m wide dam that has fresh water of depth 2.7 m on one side. Neglecting the weight of the dam calculate the reactions at A and B.

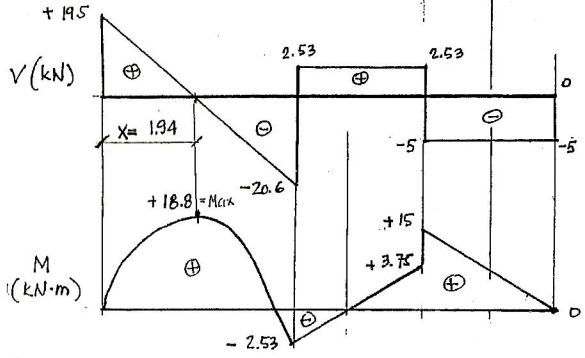
Draw the free body diagram in the space bellow:

Answers:
A = 42.6 kN 5/13
B_y = 32.7 kN ↑
B_x = 73.2 kN →



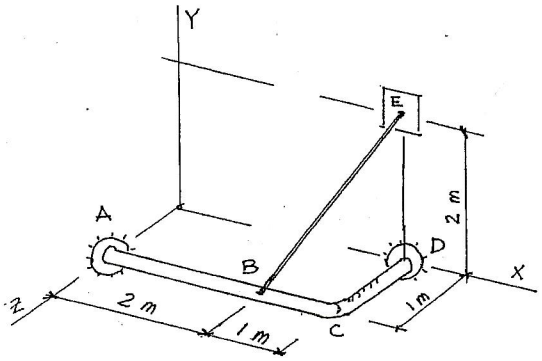
2. In the space provided plot the shear force and bending moment diagrams for the wood beam **ABCDE** and show all key values. The failure stress for the material in compression and tension is 8 MPa and the load (safety) factor is 1.9. Determine the required depth **d** for the rectangular cross section of the beam shown. Depths are available in increments of 10 mm.





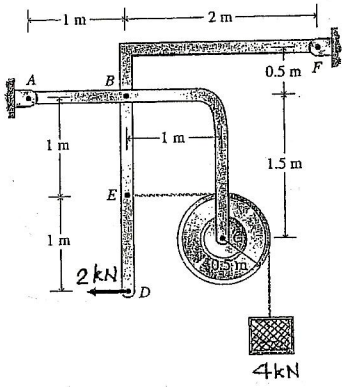
Answer:
d = 430 mm

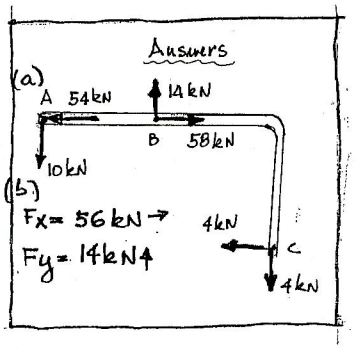
3. An L-shaped pipe bracket is supported by a ball-and socket at **A**, by a ball-and socket at **D** which has been modified to permit movement in the z direction, and by cable **BE**. The mass of the pipe segment **AC** is 2 kg/m whereas the mass of segment **CD** can be neglected. Determine the tension in cable **BE** and the components of the reaction at **D**.



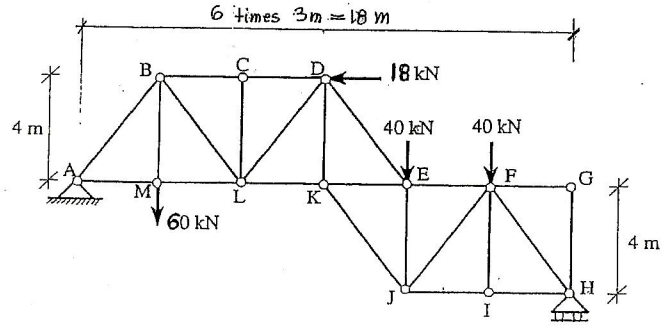
Answers:
T_{BE} = 54.1 kN (T)
D_x = 44.2 kN ←
D_y = 0
D_z = 0

4. The pulley on the pin-connected frame has a radius of 0.5 m.
a) Determine the components of the forces at the three pins on member **ABC**. Show your answers on a separate the sketch of **ABC**.
b) Determine the reaction components at **F**.





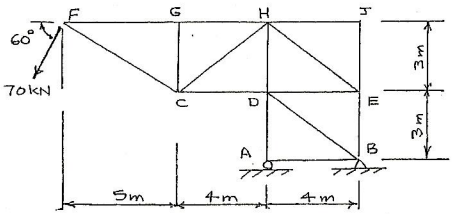
5. For the given truss shown supported by a pin at **A** and a roller at **H**,
a) determine the forces in members **EJ, LK** and **IF**,
b) determine the cross section of member **LK** if the failure stress for the material is 100 MPa and the load (safety) factor is 1.8. Assume a square cross section,
c) calculate the elongation of member **BM**. The modulus of elasticity **E**, of the material is 200 000 MPa.



Answers
a) EJ = 118 kN (C)
LK = 58.5 kN (T)
IF = 0 (zero force member)
b) for LK the cross section:
(32.4 × 32.4) mm
c) for LK: ΔL = 0.833 mm

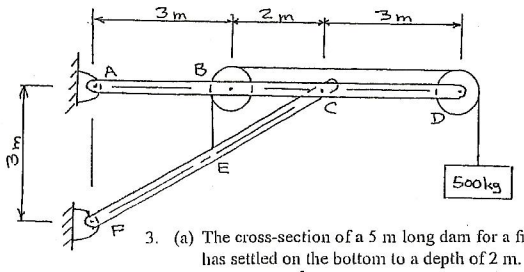
CIV 101 STRUCTURES, MATERIALS, DESIGN FINAL EXAM 2007

1. The truss shown which is supported by a roller at A and a pin at B is loaded as shown..
   (a) Determine the reaction components at A and B
   (b) Determine the forces in members CD and EH
   (c) Determine the stress in member CD and its elongation. E = 12 x 10^3 MPa and the cross-sectional area is 500 mm^2.

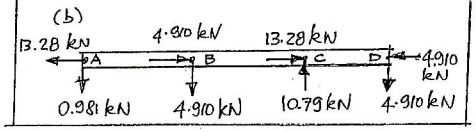


Answers:
a) A = 250kN ↑
By = 188.9 kN ↓
Bx = 35 kN →
b) CD = 181.9kN(C)
EH = 271 kN(T)
(c) σ = 364 MPa
ΔL = 121.3 mm

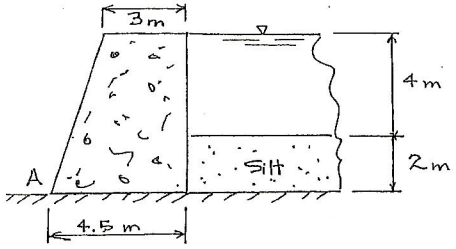
2. The pulleys in the pin-connected frame shown have a radius of 125 mm. Determine:
   (a) the reaction components at A and F
   (b) the components of the forces at the four pins on member ABCD. Show your answers on a sketch of ABCD.



Answers:
(a) Ax = 13.28 kN ← Fx = 13.28 kN →
Ay = 0.981 kN ↓ Fy = 5.89kN ↑

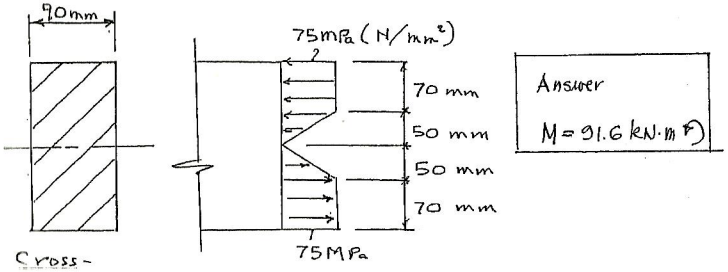
(b)


3. (a) The cross-section of a 5 m long dam for a fresh water lake is shown. Over a period of time a layer of silt has settled on the bottom to a depth of 2 m. Assuming that silt is equivalent to a liquid having a density of 1760 kg/m^3 determine the overturning moment of the silt and water about point A.



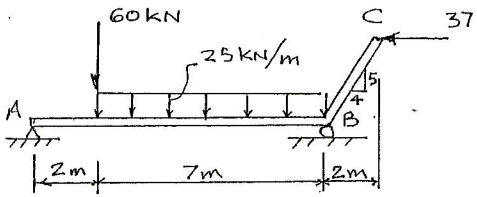
Answer:
M_A = 1815 kN·m ↺

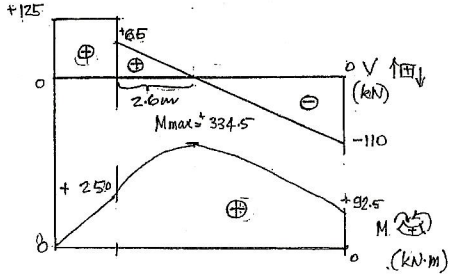
(b) A beam with a rectangular cross-section is subjected to a bending moment M which produces the stresses shown in side view. Determine the bending moment M.

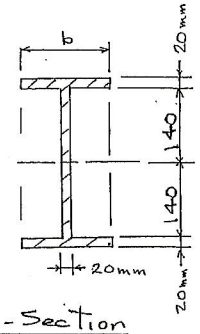


Answer
M = 91.6 kN·m ↻

4. The welded steel beam ABC which has the wide- flanged shape shown is supported by a pin at A and a roller at B. The yield stress for the steel is 380 MPa, and the plate is only available in width increments of 10 mm.
   (a) Sketch the shear and moment diagrams for AB in the space provided. Show all key values.
   (b) For the beam segment AB, determine the minimum flange width, b, assuming a load factor of 1.8.





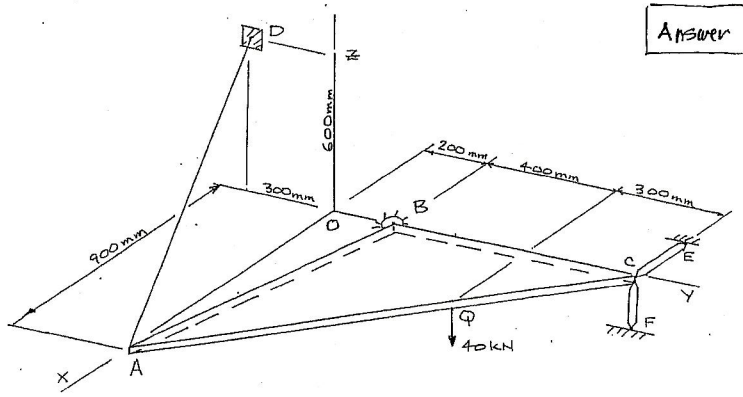


Cross-Section

Answer:
b = 250 mm

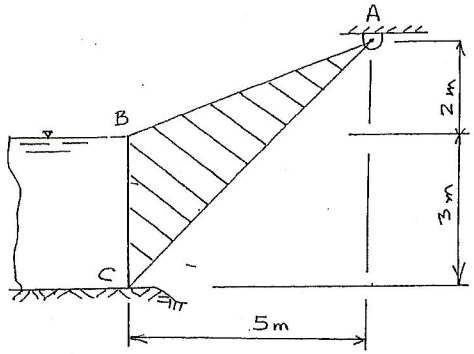
5. A uniformly thick steel plate is supported by a ball-and-socket at B, two pin-connected bars CE and CF located at C, and the cable AD. The plate which weighs 20 kN supports a vertical force of 40 kN located at Q.
   (a) Sketch a free body of the plate in the space provided; show the x and y coordinates of the 20 kN self-weight
   (b) Determine the force in the cable.

Answer : T_D = 37.5 kN (T)



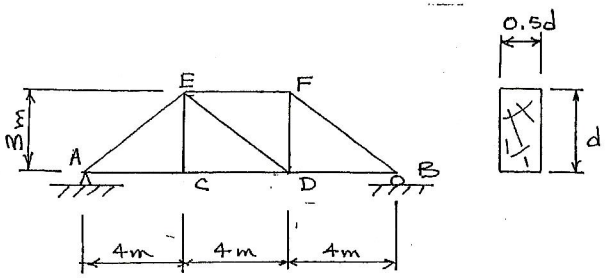
CIV 101 STRUCTURES, MATERIALS, DESIGN

1. The solid 6 m wide gate (barrier) ABC whose cross-section is shown has a uniform density of 4000 kg/m^3. It is used to control flow in a fresh water smooth-bottomed channel. Determine the reaction components at the hinge A and at the contact point C.



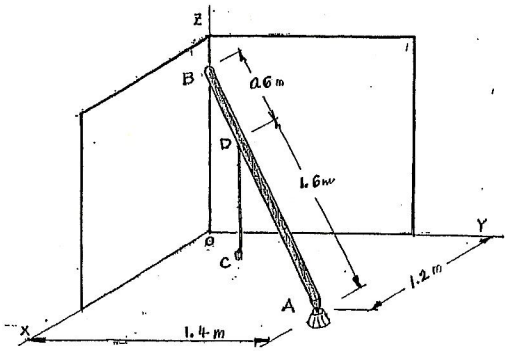
Answers:
C_y = 1389 kN ↑
A_y = 377 kN ↑
A_x = 265 kN ←

2. The timber truss shown, which is supported by a pin at A and a roller at B, is subjected to a single vertical load P = 117 kN which can act at either point C or point D. Considering both cases, determine the required cross-section for member ED assuming that the failure stresses for the timber are 10 MPa in tension and 15 MPa in compression. Use a load factor = 2.4, and E = 12 x 10^3 MPa. The cross-section is also shown.



Answers:
case1: ED = 65 kN (C)
Yield: d = 144.2 mm
buckl: d = 237.1 worst
case2: BD = 65 kN (T)
yield: d = 177 mm
Use 240 x 120 mm

3. The 2.2 m uniform bar AB is supported by a ball-and-socket at A and two smooth walls at B, one in the x-y plane and one in the y-z plane. The bar weighs 400 N/m and the tension in the vertical cable CD is 2 kN. Sketch the free body diagram for the bar AB, and determine the reaction components at A and B.



Answers:
A_x = 1.895 kN ↗
A_y = 2.21 kN ←
A_z = 2.88 kN ↑
B_y = 1.895 kN →
B_x = 2.21 kN ↙

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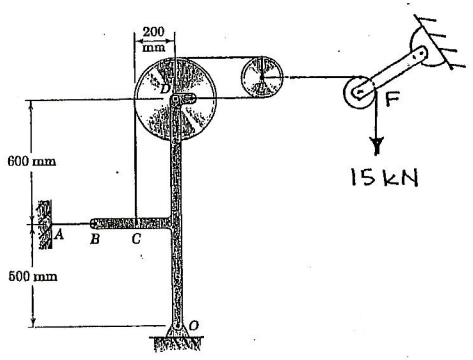
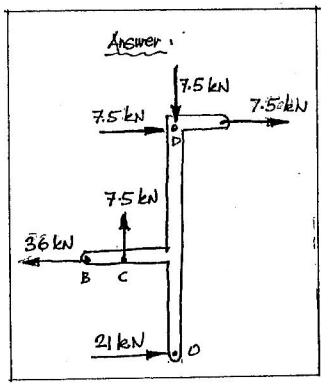
4. The pin-connected frame is supported by a cable AB and a pin at O. Neglecting the weights of all of the components determine:
   (a) the force in the cable AB and the reaction components at O
   (b) the force components acting at B, C, D, and O of member BCDO. Show the force components on a sketch of BCDO.





5. A simply supported emergency pedestrian bridge spans 10 m; one of the beams is shown in Figure A. The bridge consists of a timber deck fastened to two beams each made from two127 x 76 x 8 hollow structural sections (HSS) as shown in the cross-section. The load on the bridge consists of a uniform load of 1.5 kN/m^2 which includes the self-weight of the bridge, and two concentrated loads of 10 kN, one on each beam. Assume that the yield stress for the steel is 350 MPa. The properties of the HSS are given below.
   (a) Sketch the shear and moment diagram for one beam
   (b) Determine the maximum stress in the beams due to bending moment
   (c) Comment on the adequacy (safety) of the beams..

RECTANGULAR Hollow Structural Sections

Designation	Size	Mass	Dead Load	Area	I_x	S_x	r_x	Z_x	I_y	S_y	r_y	Z_y	Torsion J	Shear C_{rt}
mm x mm x mm	mm x mm x mm	kg/m	kN/m	mm^2	10^6 mm^4	10^3 mm^3	mm	10^3 mm^3	10^6 mm^4	10^3 mm^3	mm	10^3 mm^3	10^3 mm^4	mm^2
HSS 127x76x9.5	HSS 127x76.2x9.53	25.7	0.252	3 280	6.12	96.4	43.2	126	2.69	70.5	28.6	87.5	6 600	1 690
x 8.0	x 7.95	22.1	0.217	2 820	5.49	86.4	44.1	111	2.43	63.8	29.4	77.2	5 810	1 510
x 6.4	x 6.35	18.2	0.178	2 320	4.70	74.0	45.1	93.3	2.10	55.1	30.1	65.2	4 890	1 290
x 4.8	x 4.78	14.1	0.138	1 790	3.78	59.5	45.9	73.8	1.70	44.7	30.8	51.7	3 860	1 030

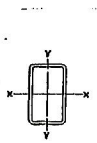
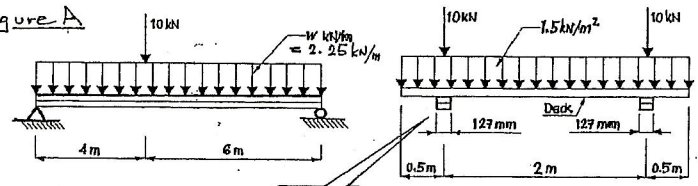


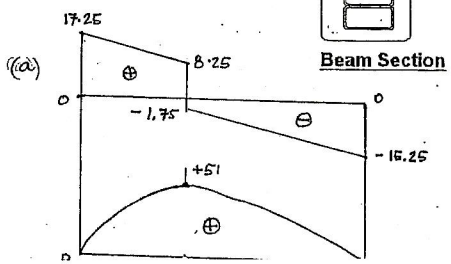
Figure A



Beam

Beam Section

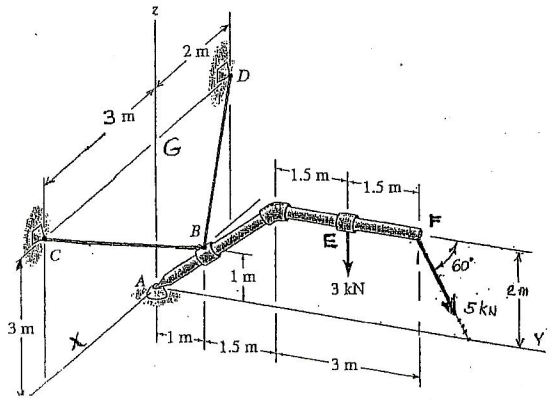
Cross-Section of the Whole Bridge



Answers:
(b) σ_{max} = 298 MPa
(c) 350 > 298 safe for ped. bridge but (safety) load factor 1.175 only.

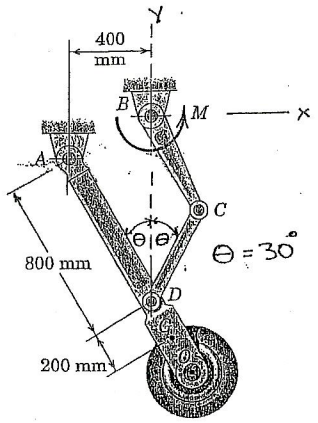
CIV 101 STRUCTURES, MATERIALS, DESIGN FINAL EXAM 2006

1. A pipe-assembly, which is held in place by a ball-and-socket at A and by two cables, supports two loads both of which lie in the y-z plane. The weight of the pipes themselves can be neglected. Determine the tensions in the two cables, and the reaction components at A.



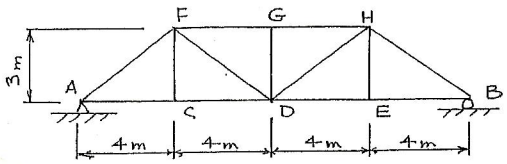
Answers:
BD = 25.2 kN (T)
BC = 21 kN (T)
A_x = 0
A_y = 11.52 kN →
A_z = 21 kN ↓

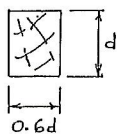
2. The nose-wheel assembly for an airplane is raised by the application of a moment M to member BC applied through the shaft at B. Member AO and the wheel have a combined mass of 50 kg, and the centre of mass for the two elements is at G. Members DC and CB are both 500 mm long and their masses can be neglected. Determine the required value of M to hold the assembly in the equilibrium position shown.



Answer: M = 153.3 N·m ↻

3. The timber truss shown is supported by a pin at A and a roller at B. The truss supports a single vertical load of 120 kN which can act at either joint C or joint D but not both. Failure stress for the timber is 12 MPa in tension and 15 MPa in compression, and E = 12 x 10^3 MPa.
   (a) Determine the force in member FD for each of the two possible loadings
   (b) Given that the cross-section for member FD is to be rectangular as shown, and that the load factor is 2, determine the minimum cross-sectional dimension "d" to the nearest 5 mm.



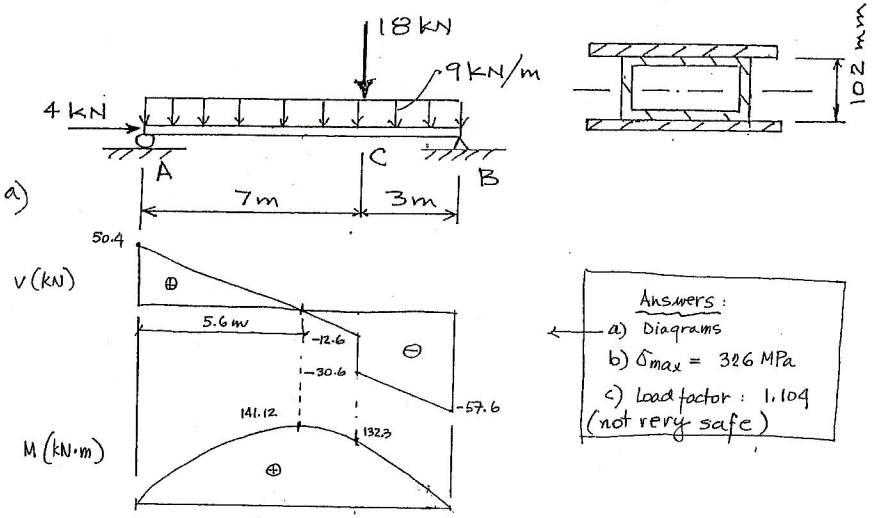


Answers
(a) load at C: FD = 50 kN (C)
load at D: FD = 100 kN (T)
(b) cross section chosen:
d = 190 mm:
190 mm
115 mm

4. A simply supported beam for an office building has been fabricated from a 203 x 102 x 8 HSS section and two 300 mm x 10 mm plates; the service loading used for the design is shown. The cross-section of the beam and the properties of the HSS section are given below. The yield stress for the steel is 360 MPa.
   (a) Sketch the shear and moment diagrams in the space provided. Show all key values.
   (b) Determine the maximum stress in the steel caused by the bending moment.
   (c) Determine the apparent load factor based on yield and comment on the adequacy (safety) of the beam.

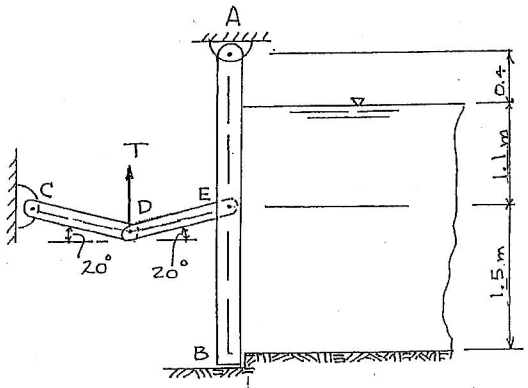
RECTANGULAR Hollow Structural Sections

Designation	Size	Mass	Dead Load	Area	I_x	S_x	r_x	Z_x	I_y	S_y	r_y	Z_y
mm x mm x mm	mm x mm x mm	kg/m	kN/m	mm^2	10^6 mm^4	10^3 mm^3	mm	10^3 mm^3	10^6 mm^4	10^3 mm^3	mm	10^3 mm^3
HSS 203x102x13	HSS 203x102x12.7	52.4	0.514	6 680	31.2	307	68.4	405	10.2	201	39.1	246
x 11	x 11.1	46.8	0.460	5 970	28.7	282	69.3	367	9.48	186	39.8	224
x 9.5	x 9.53	40.9	0.401	5 210	25.8	253	70.3	325	8.56	168	40.5	199
x 8.0	x 7.95	34.8	0.341	4 430	22.5	221	71.2	281	7.54	148	41.2	172
x 6.4	x 6.35	28.3	0.278	3 610	18.6	185	72.2	232	6.35	125	42.0	143
x 4.8	x 4.78	21.7	0.213	2 760	14.7	145	73.1	180	5.03	99.0	42.7	111



Answers:
a) Diagrams
b) σ_{max} = 326 MPa
c) Load factor: 1.104
(not very safe)

5. A gate in a salt-water canal is hinged at A as shown, and held closed by the pin-connected assembly CDE. The canal is 3.2 m wide and the density of the salt water is 1040 kg/m^3. Determine the minimum vertical tension force, T, required to keep the gate closed.



Answer: T = 114.1 kN ↑