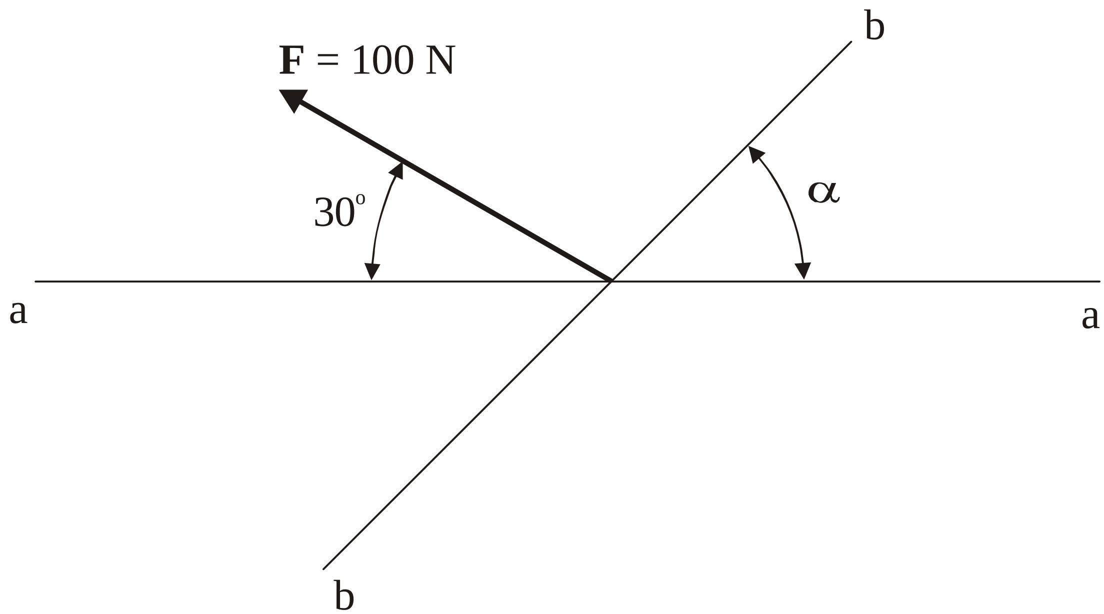
ENG 1440
INTRODUCTION TO STATICS
SERIES II
PROBLEM SET

S2-201 A force ***F*** of magnitude *100 N* makes an angle of 30^o with respect to the *a-a* axis as shown in the Figure. If the magnitude of the component of ***F*** along the axis *a-a* is $F_a = 120\ N$, determine:

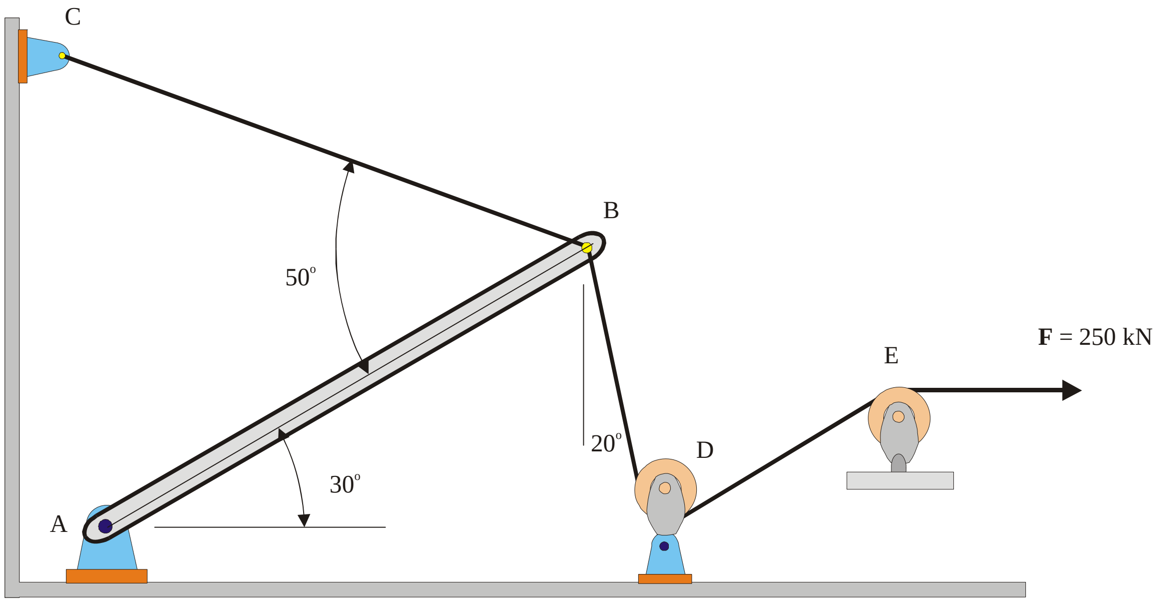
(a) F_b, the magnitude of the component of ***F*** along axis *b-b*, and

(b) the angle α that the axis *b-b* makes with the axis *a-a*.



S2-202 A *250 kN* force is applied to a cable as shown in the figure. The cable passes over two smooth pulleys and is attached to a wooden boom at *B*. A second cable, *BC*, is attached to the boom at *B* and the wall at *C*. The resultant, ***R***, of the two cable forces applied to the boom at *B* is directed along the boom from *B* towards *A*.

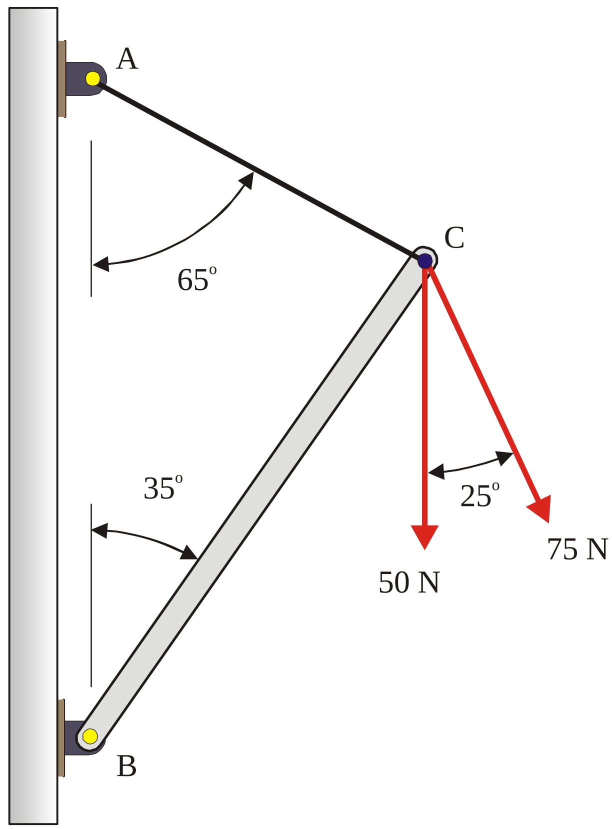
a) Determine the magnitude of the resultant, *R*.
b) Determine the magnitude of the tension in cable *BC*.



S2-203 For the Figure shown below, determine:

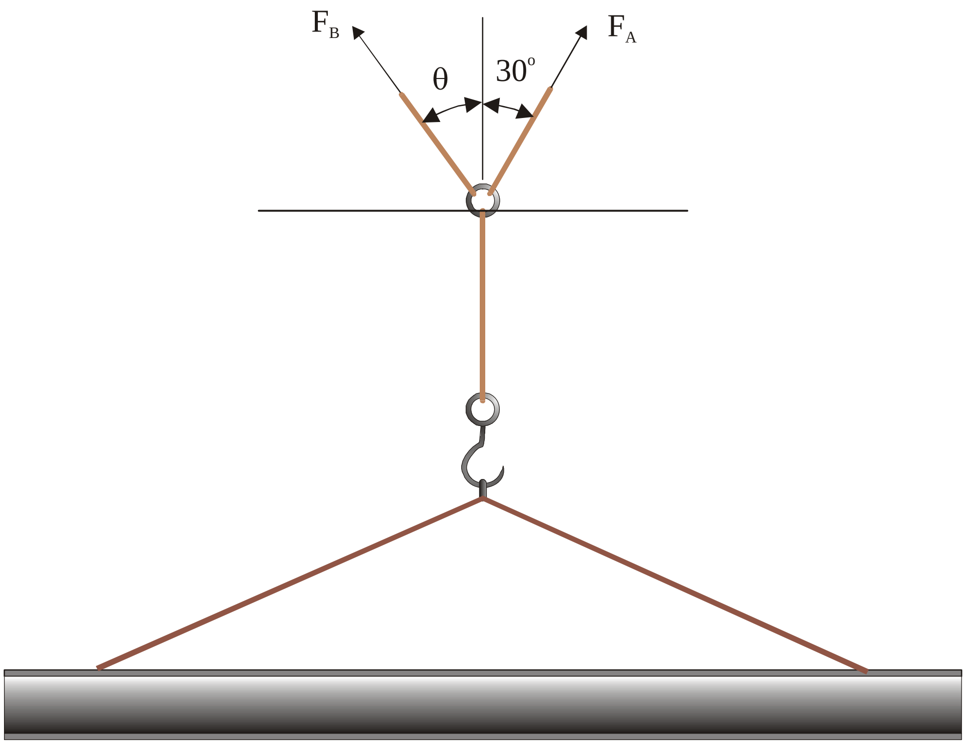
(a) the required tension in cable *AC*, knowing that the resultant of the three forces exerted at point *C* (resultant of 50 N, 75 N and $\mathbf{T_{AC}}$) of boom *BC* must be directed along *BC*,

(b) the corresponding magnitude of the resultant.



S2-204 A beam is hoisted using two chains attached to a ring as shown in the figure. The resultant, $\boldsymbol{R}$, of the two chain forces $\boldsymbol{F_A}$ and $\boldsymbol{F_B}$ is $600\ N$ and is directed along the positive y axis. $\boldsymbol{F_A}$ acts at 30^o from the y axis as shown.

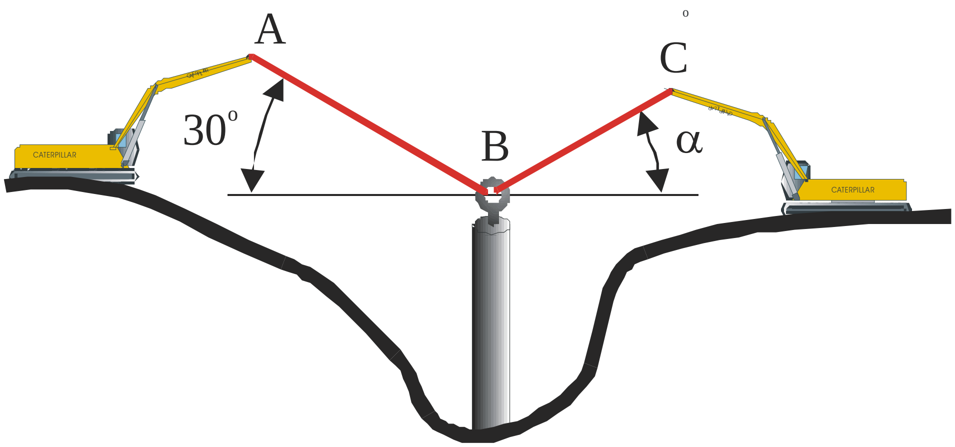
Determine the magnitude of the two chain force $\boldsymbol{F_A}$ and $\boldsymbol{F_B}$ and the angle θ such that the magnitude of force $\boldsymbol{F_B}$ is a minimum.



S2-205 Two cranes are attempting to pull a precast pile from an excavation.. The tension in cable *AB* attached to the ring at B is *3 kN*. Determine by trigonometry:

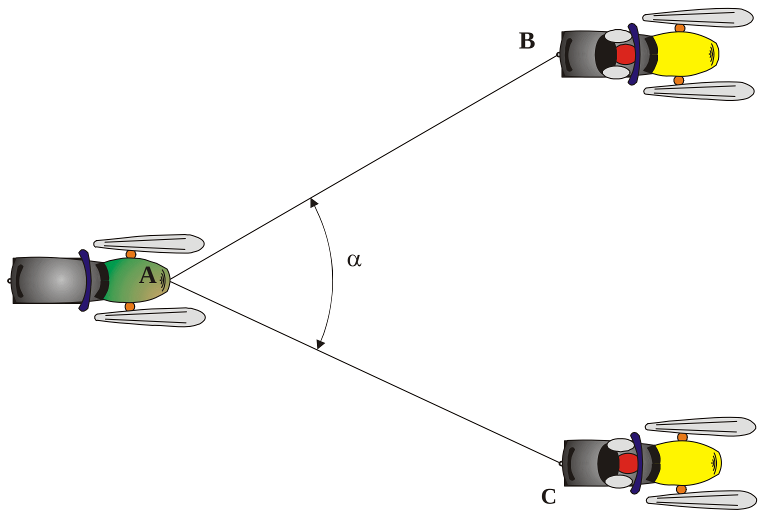
a) the magnitude and direction of the smallest tension force in cable *BC* attached to the second crane such that the resultant ***R*** of the two force applied to the pile at *B* is vertical.

b) the corresponding magnitude of ***R***



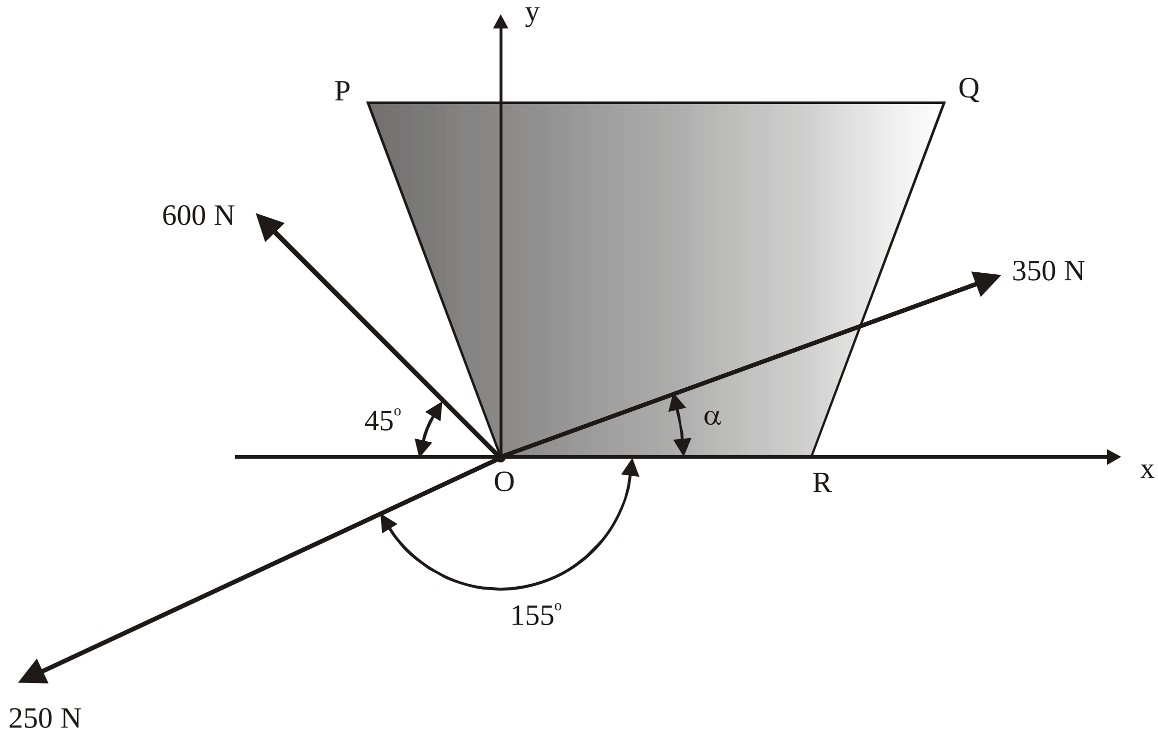
S2-206 Two snowmobiles are pulling a third snowmobile each exerting a force of *3 kN* at the attachment point at *A*. The maximum combined force that the two cables can exert on the attachment to the third snowmobile in any direction is *5 kN*. Assume that $0 \le \alpha \le 90^{\circ}$. Determine the range of α before the *5 kN* is exceeded:

a) By means of a graphical solution, and
b) Using a trigonometry (sine and/or cosine rule).



S2-207 Three forces of *250 N*, *600 N* and *350 N* are applied to the trapezoidal plate *OPQR* as shown in the figure.

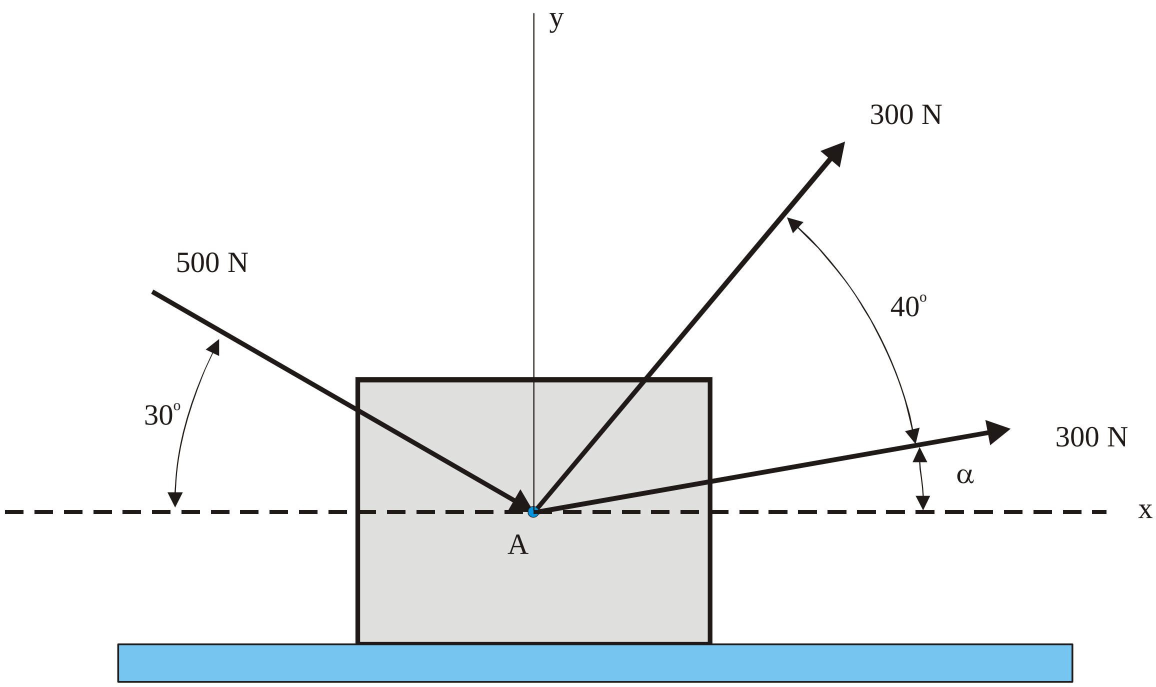
a) Using graphics determine the resultant (magnitude and direction) of the *600 N* and the *250* N forces,
b) Using trigonometry (sine and/or cosine rule determine the resultant (magnitude and direction) of the *600 N* and the *250 N* forces.
c) Determine the angle α for which the resultant of the three forces is horizontal.



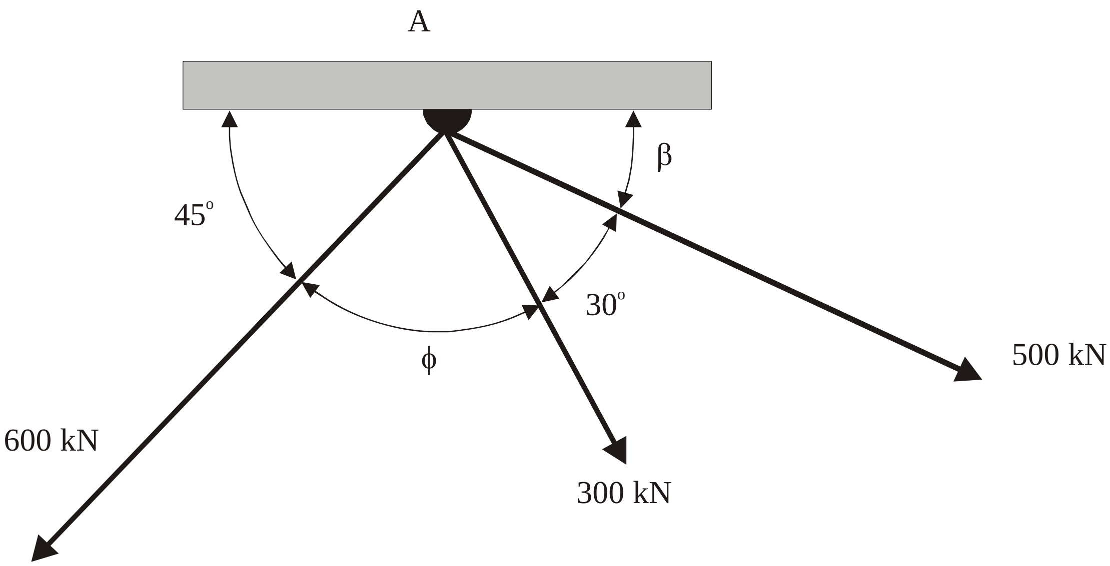
S2-208 Two *300 N* forces and a *500 N* force are applied to the block at point *A* as shown in the figure. All of the forces are in the *x-y* plane.

a) If angle $\alpha = 20^o$ determine the magnitude and direction of the resultant force exerted at the point *A*.

b) Determine the value of the angle α for which the resultant of the three forces is in the *x* direction.



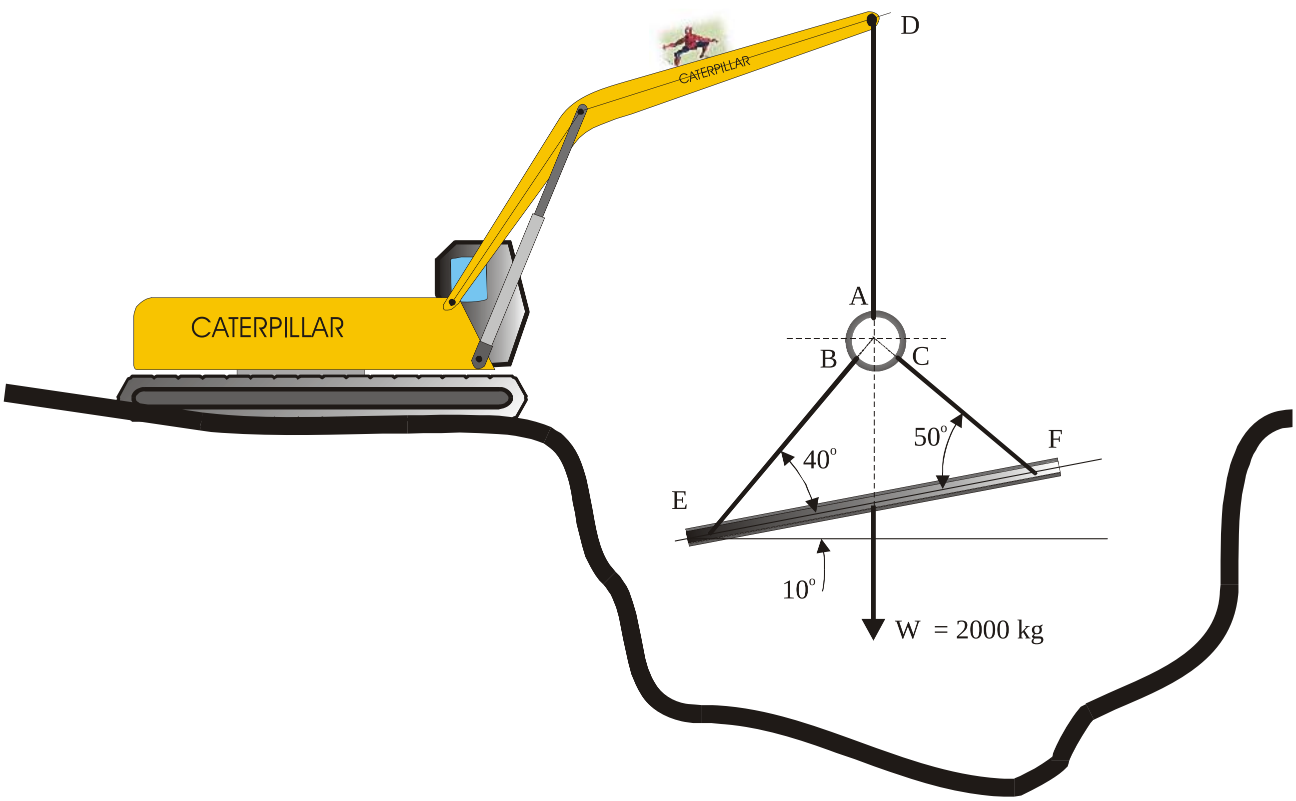
S2-209 Three forces are applied at point *A* as illustrated in the figure. Determine the angle β for which the resultant, ***R***, of the three forces will be directed vertically downward.



S2-210 A crane is lifting a *2000 kg* steel beam. Determine the forces in the three cables (*AD*, *BE* and *CF*) attached to the ring at *A*, *B*, and *C* if the resultant of these three forces acting on the ring is zero when the beam is in the position shown in the figure below. Neglect the radius of the ring.

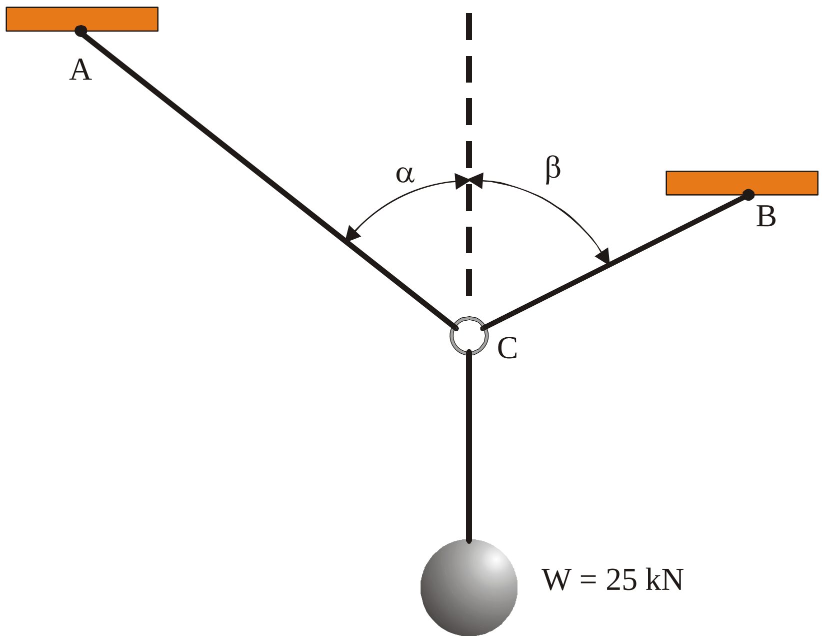
a) Present a graphical solution to this problem and state the scale you are using.
b) Present a trigonometry solution.

Use g (gravity acceleration) = 9.8 m/sec^2

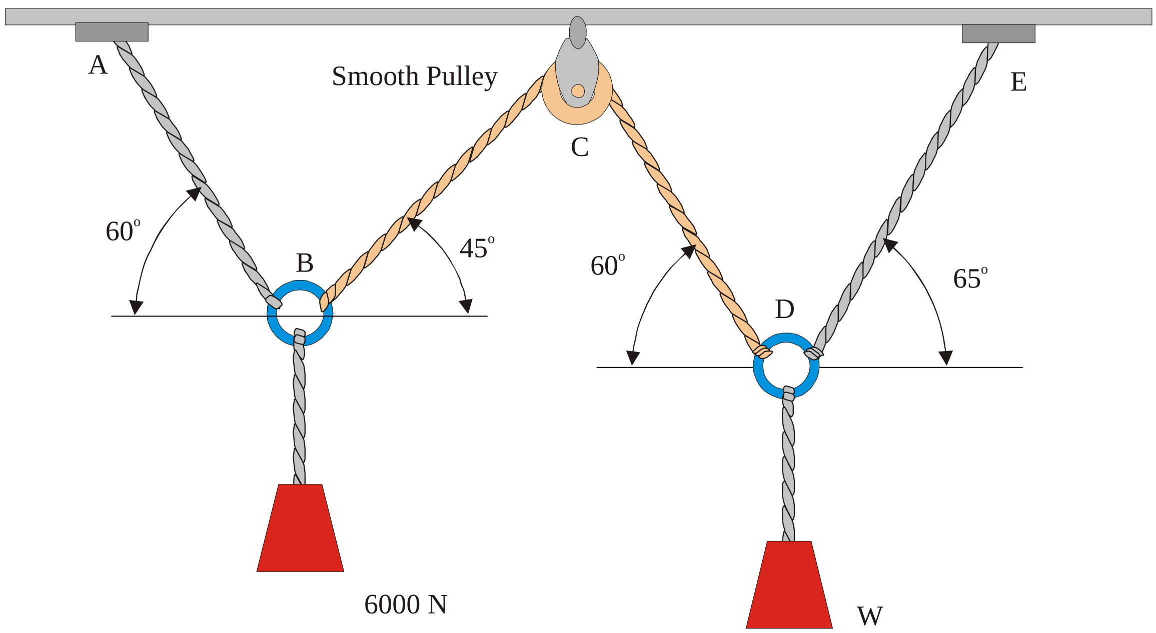


S2-211 Two cables AC and BC are tied to a ring at C. A 24 kN weight is suspended from the ring. The tension in cable BC is 16 kN and the tension in cable AC is 12 kN. Determine the angles α and β:

a) by a graphical solution, and
b) by trigonometry.



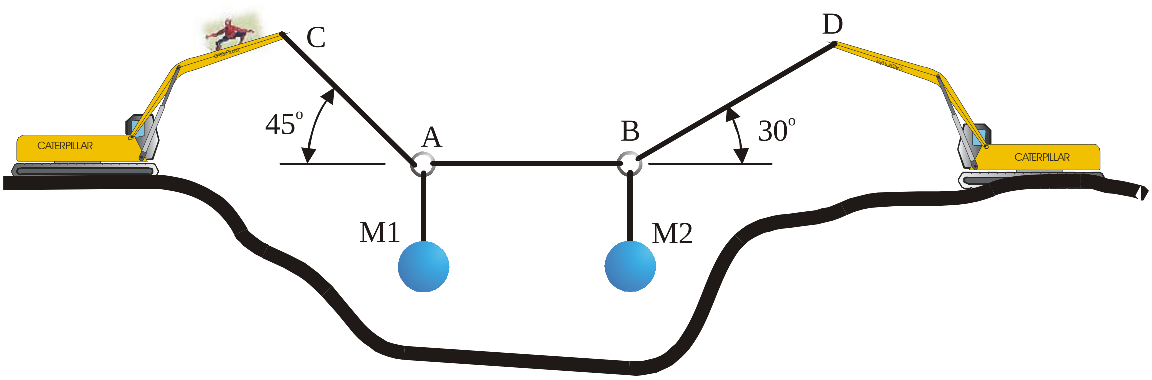
S2-212 In the figure below, the cable *BCD* passes over a smooth pulley and is attached to a ring at *B* and a ring at *D*. Cables *AB* and *DE* are attached to the rings at *B* and *D* and to the ceiling at *A* and *E*.
A *6000 N* weight is suspended from the ring at *B* and a weight, *W,* is suspended from the ring at *D*.
Determine the weight *W* and the tensions in cables *AB*, *BC*, *CD* and *DE*.



S2-213 Two cranes are used to lift two masses, *M1* and *M2* using a set of three cables (*AC*, *AB*, and *BD*) attached as shown in the figure. Cable *AB* is horizontal.

What would be the maximum combined mass *(M1 + M2)* that the two cranes can lift if the maximum force that any one of the three cables *AC*, *AB* or *BD* can carry is *100 kN*?

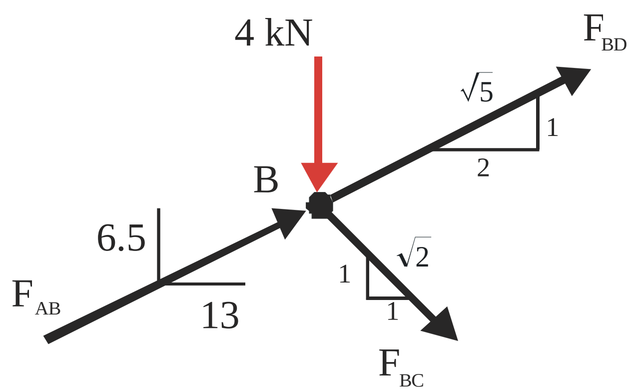
Use g = 9.8 m/sec^2



S2-214 Four forces act on a pin that is in equilibrium. The senses of $\boldsymbol{F_{BD}}$ and $\boldsymbol{F_{BC}}$ as shown in the given Free Body Diagram (FBD) are assumed. The vertical and horizontal components of force $\boldsymbol{F_{AB}}$ are shown on the vertical and horizontal lines attached to $\boldsymbol{F_{AB}}$ (we call these "placeholders").

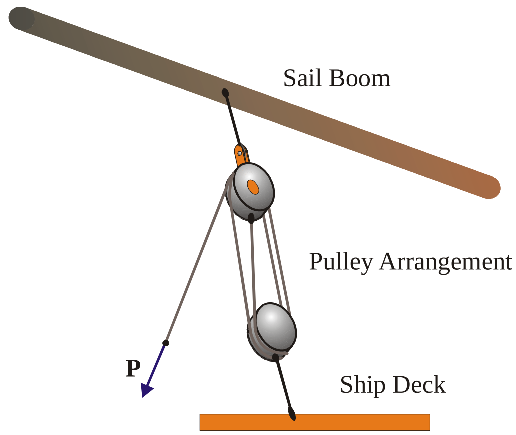
Determine:

a) The magnitude and direction of $\boldsymbol{F_{BD}}$ and $\boldsymbol{F_{BC}}$,
b) Redraw the FBD indicating the horizontal and vertical components on "placeholders" and
c) Demonstrate graphically (using the vertical and horizontal components of each force) that the pin is in equilibrium.

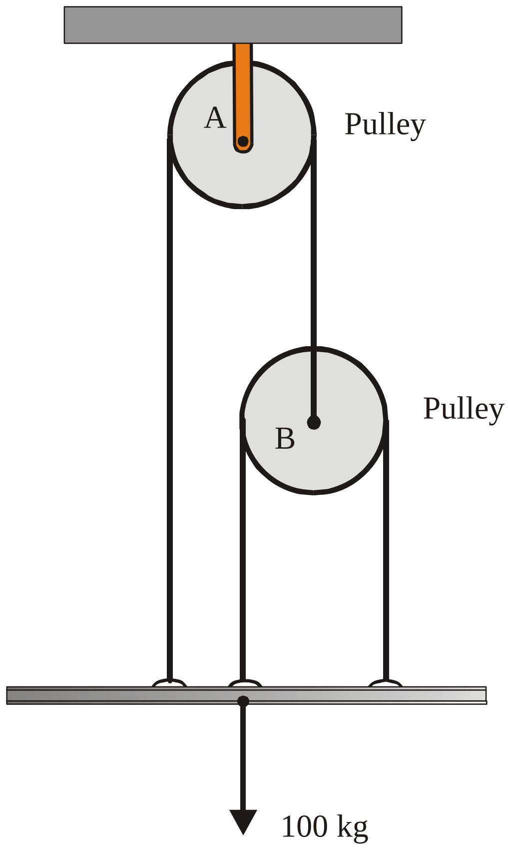


S2-215 A pulley arrangement is used to raise and lower one of the sails of the Bluenose II. One of the pulleys is attached to the sail boom and the other is attached to the deck of the ship. If a crewmember can pull with a force, ***P*** of *500 N* on the pulley rope, what is the force exerted on the sail boom.

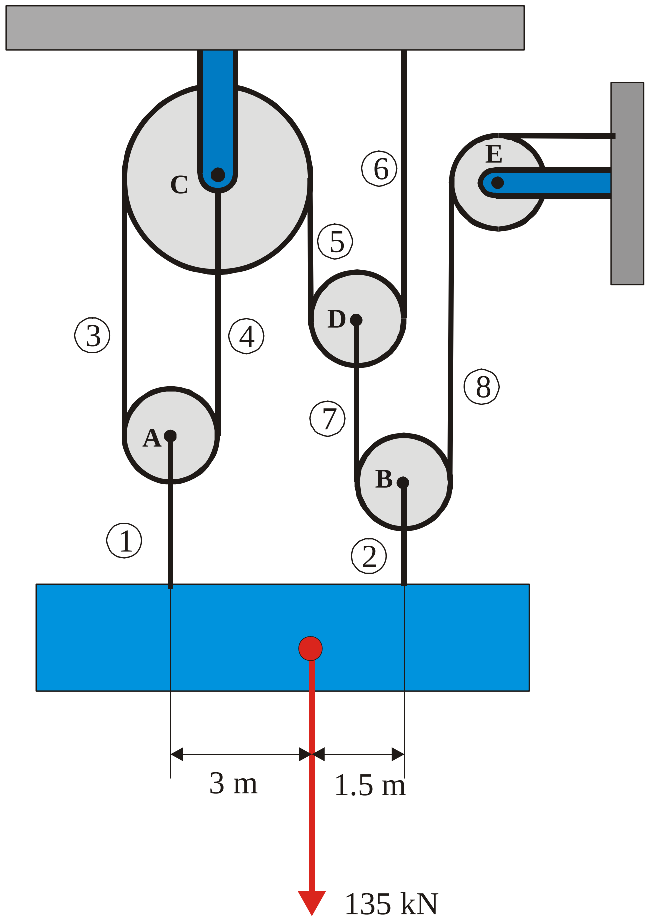
Assume all cables are vertical.



S2-216 Two pulleys arranged as shown support a beam having a mass of *100 kg*. The beam is horizontal. Determine the tension in the cord that passes over pulley *A* and the tension in the cord that passes over pulley *B*.



S2-217 The pulley arrangement shown supports a concrete block that weighs 150 kN. Determine the tension in cables 1,2,3,4,5,5,7, and 8.



S2-218 A large truck is stuck on the centerline of Fermor Avenue as shown. A single tow truck is brought in but it cannot move the large truck as shown in Figure1(a). A force of *45 kN* directed along the centerline of Fermor is required to move the large truck. A second tow truck is brought in. The two tow trucks are now attached as shown in Figure 1(b).

Determine the tension in each of the tow cables *AB* and *AC* when the large truck begins to move.

a) By means of a graphical solution (state the scale that you use),
b) By means of a trig solution applying the sine and/or cosine rules, and
c) By rectangular components.

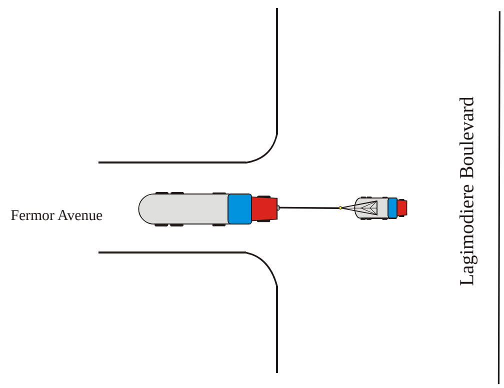
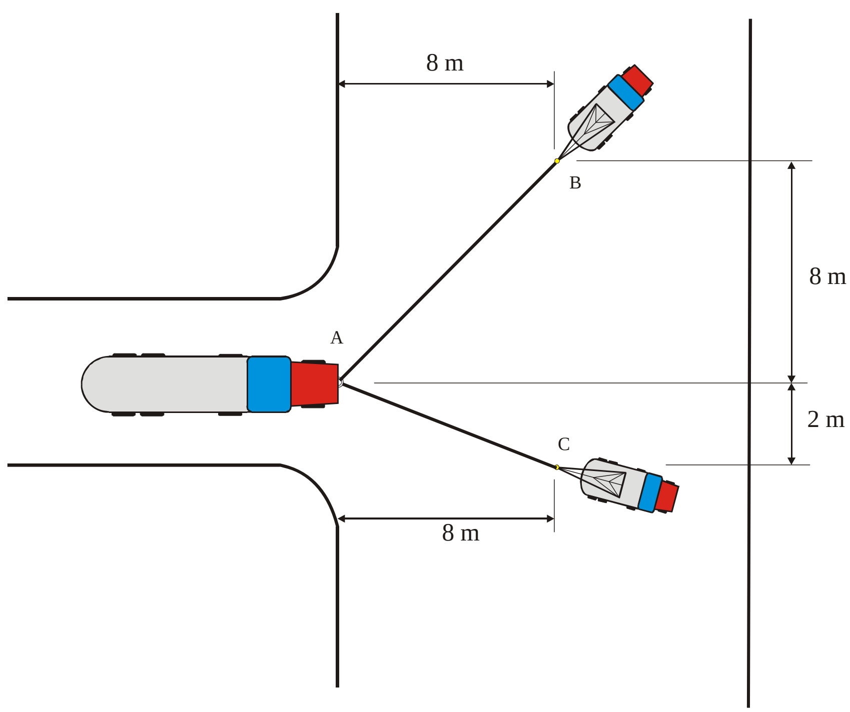
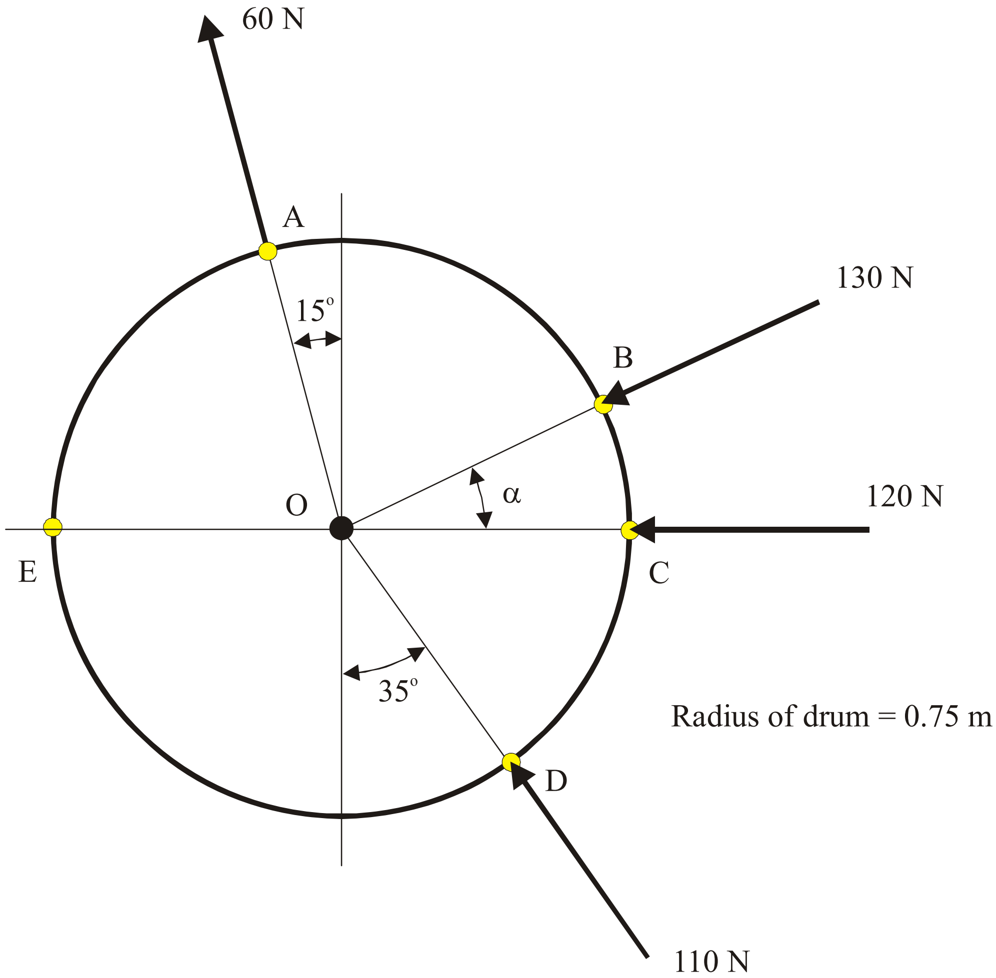


Figure 1(a)



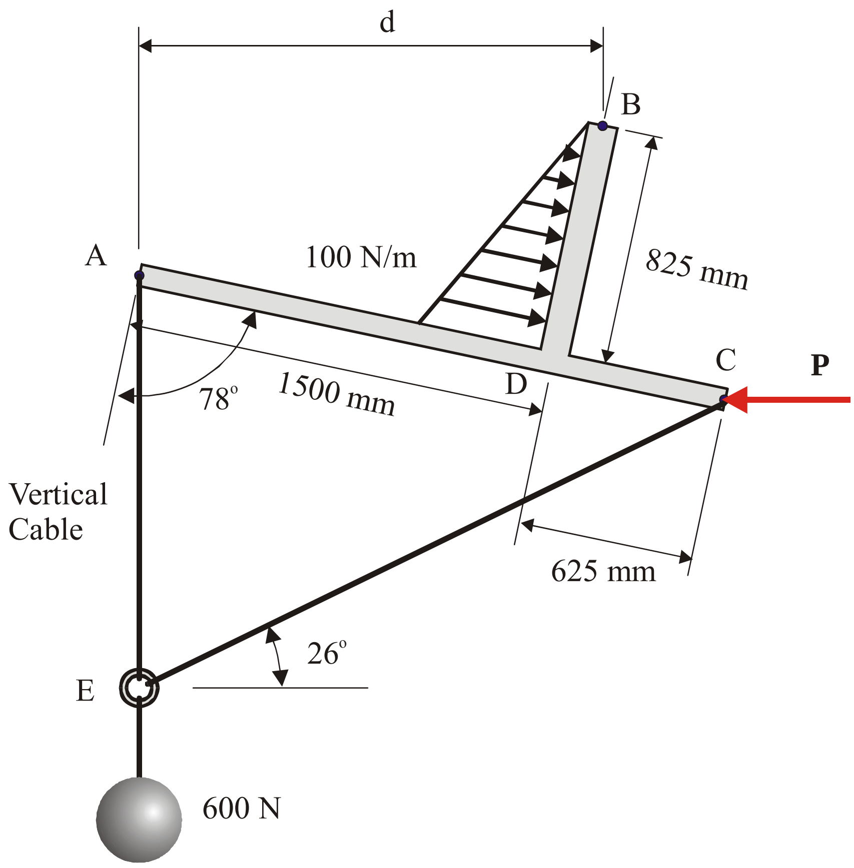
S2-301 Four forces act on a drum as shown in the figure. The radius of the drum is *0.75 m* (*diameter = 1.5 m*). The total moment of the four forces about the point *E* is equal to *50 N.m counterclockwise*.

Determine the angle α that the *130 N* force makes with the horizontal.



S2-302 A T-shaped structure is acted in by a distributed load that varies from *100 N/m* to *0 N/m* and by a force ***P***. Attached at *A* and C are two cables. Each of the cables is attached to a ring at *E*. A *600 N* weight is suspended from the ring.. The structure can rotate about *B*, but is held in the position shown by the force ***P***.

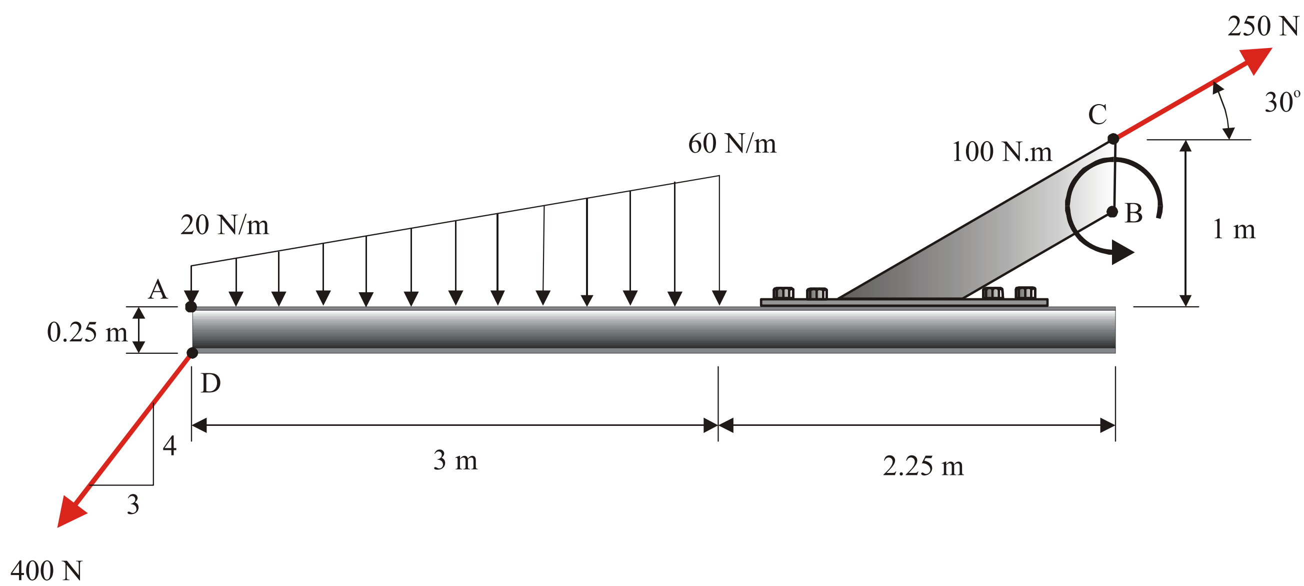
a) From the geometry of the problem, determine the distance *d*,
b) If the total moment about *B* is equal to zero, what is the magnitude of force ***P***, and
c) Determine the tensions in cables *EA* and *EC*.



S2-203 A distributed load that varies from *20 N/m* to *60 N/m* is applied to a beam as shown in the figure. A *400 N* force is applied at Point D. A *100 N.m* couple-moment and a *250 N* force act on a bracket that is attached by bolts to the beam.

Determine:

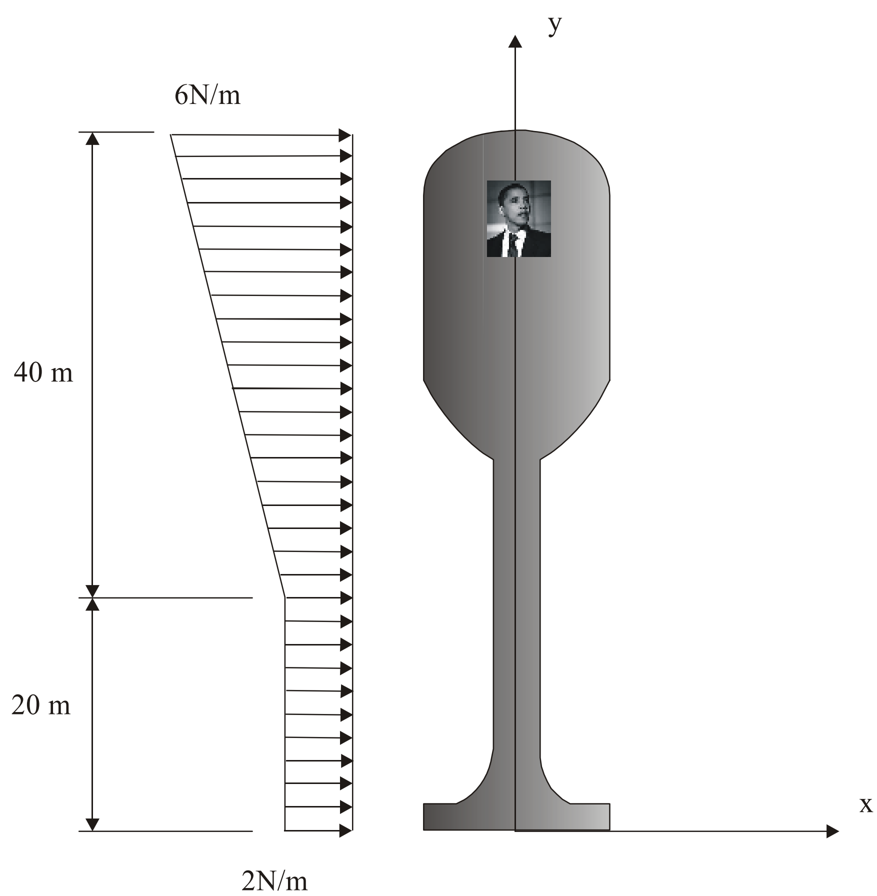
a) The equivalent force-couple at point A, and
b) The magnitude and direction of the minimum force applied at Point C that will produce the same moment about point A.



S2- 304 The wind load on a water tank outside Winnipeg is shown in the figure below. The total weigh of the water and the tower is *1000 N*.

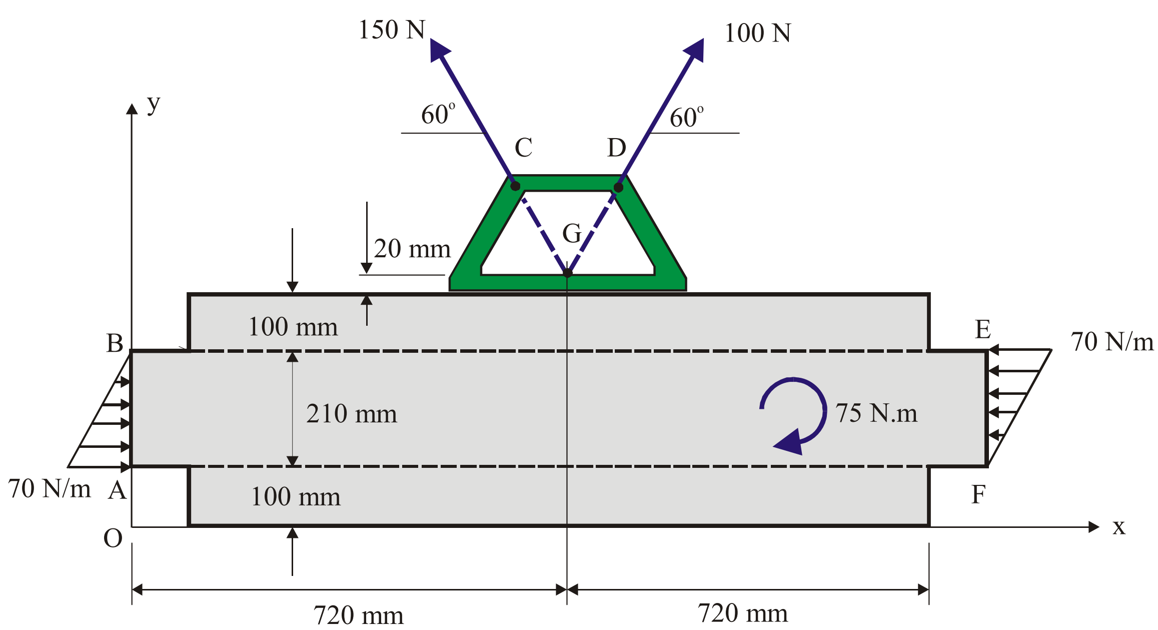
a) Find the equivalent force-couple at the intersection of the x and y axis.

b) Replace the force system by a single force and determine where the line of action of this force crosses the x and y axis.



S2-305 For the plate with a “handle” attached and loaded as shown determine:

a) Determine the magnitude and direction of the couple formed by the distributed loads applied to the plate.
b) Determine the equivalent force-couple at *O*.
c) Replace the equivalent force-couple by a single force and determine where its line-of-action intersects the *x* and *y* axis.



S2-306 A sign structure has four forces and a couple-moment applied to it in the location shown in Figure 1 below.

a) Determine the equivalent force-couple system at *A*.

b) Replace the system of forces and couples by a single force and determine where the line of action intersects the lines *x* axis and the *y* axis.

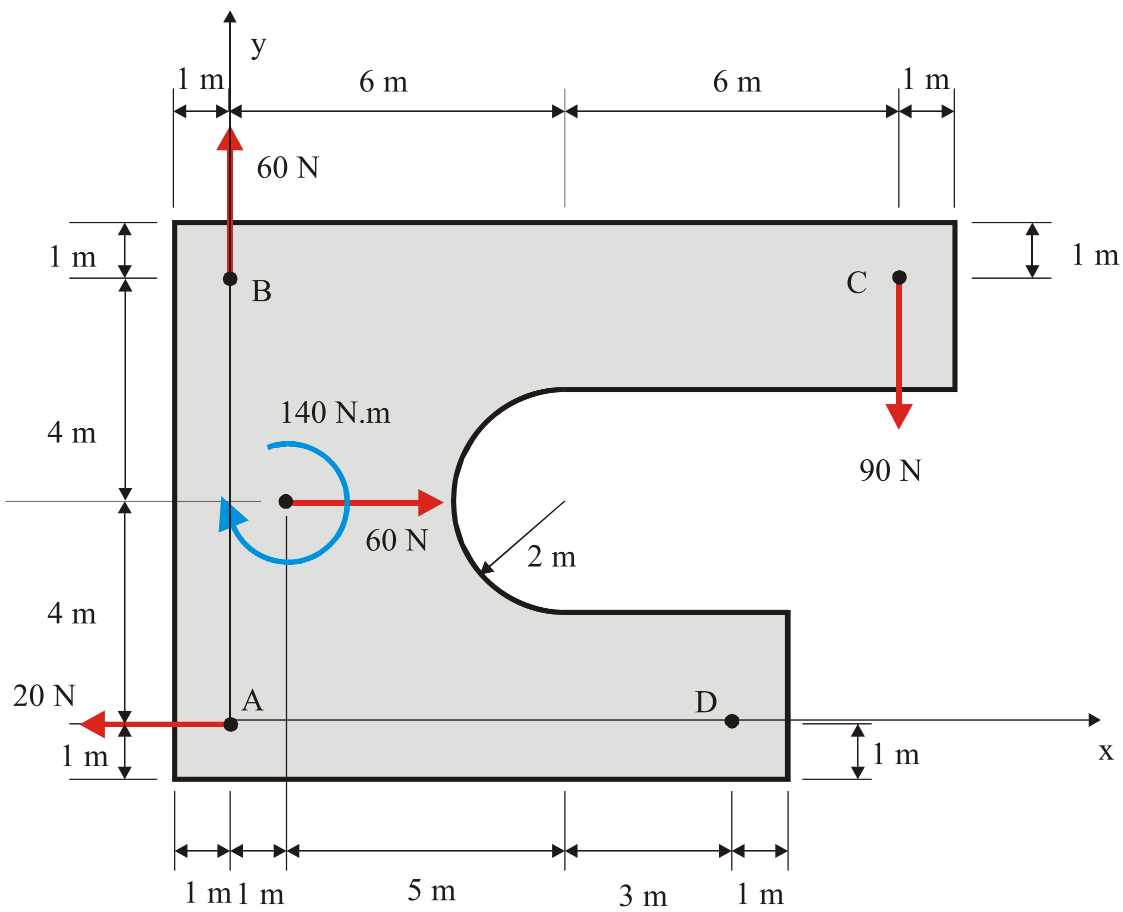
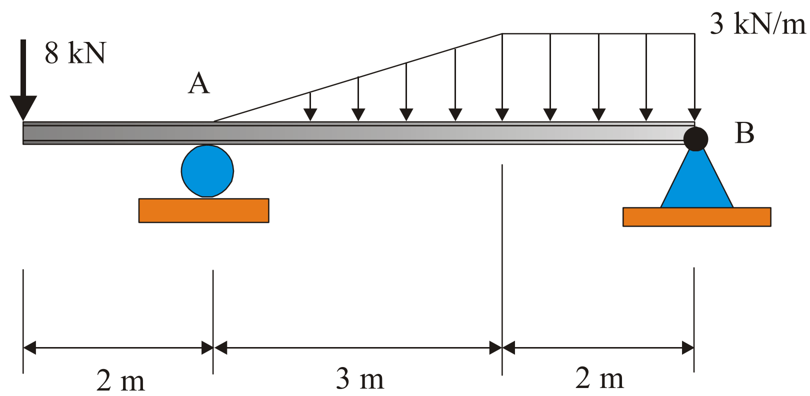
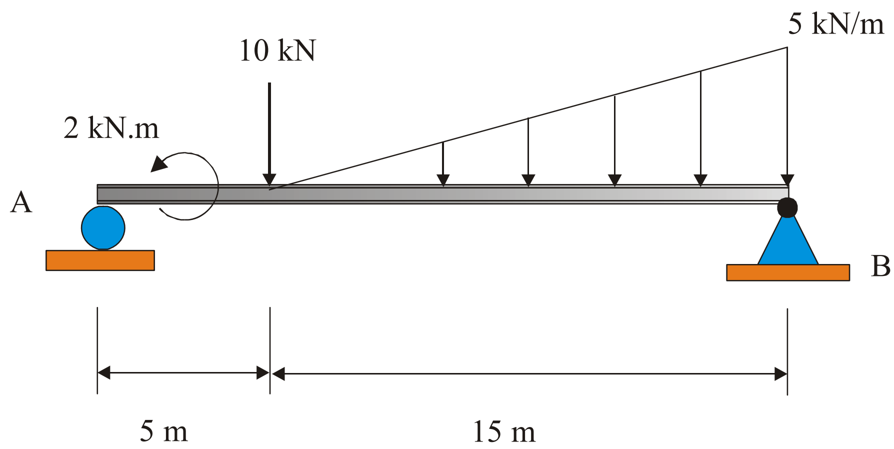


Figure 3

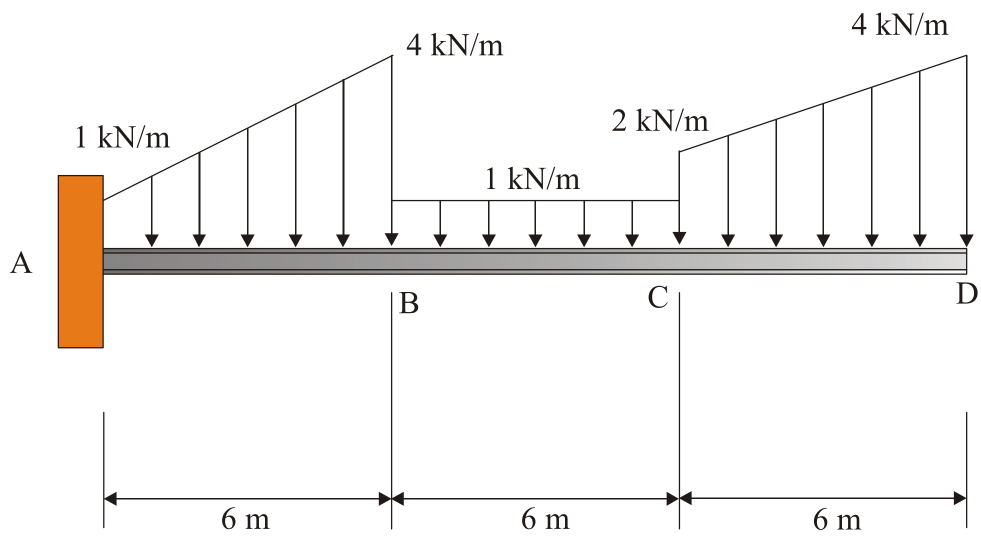
S2-307 Determine the support reactions at A and B for the propped cantilever beam.



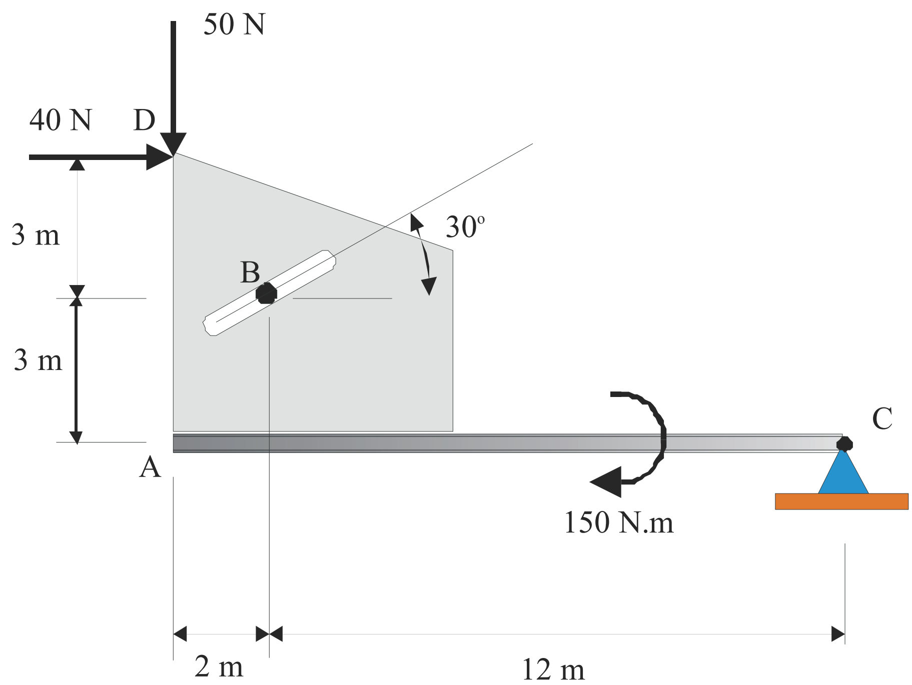
S2-308 Draw the FBD and determine the reactions a supports A and B for the beam loaded as shown.



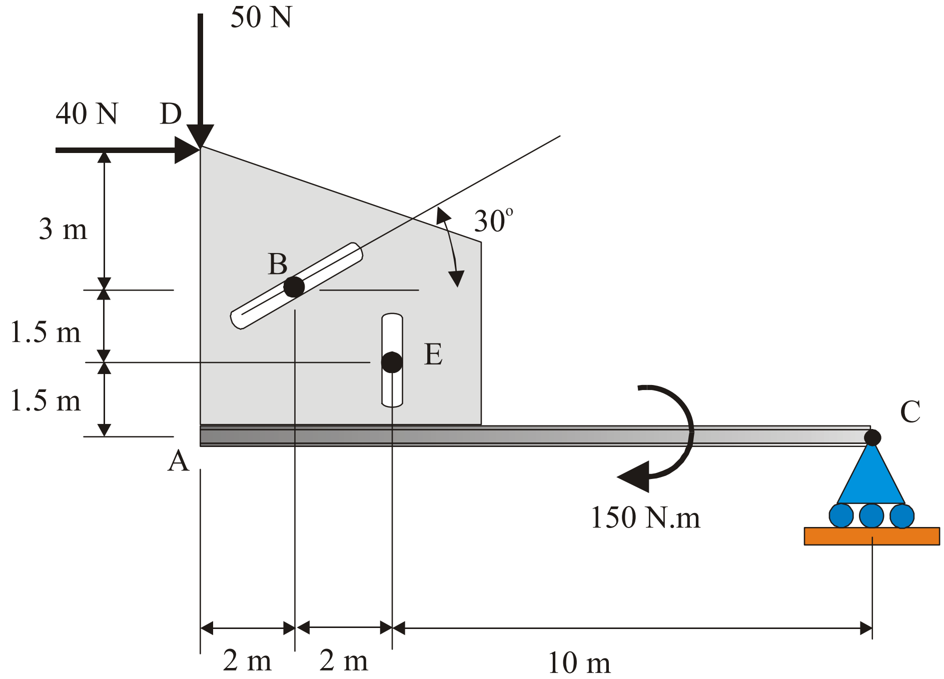
S2-309 Draw the FBD and determine the reactions at support A for the cantilever beam.



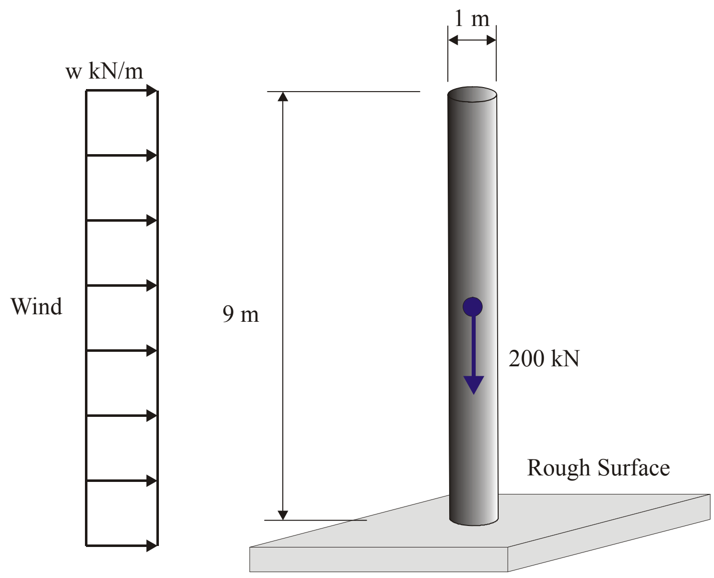
S2-310 A plate that is welded to a beam has a *50 N* and a *40 N* load applied at *D*. The beam has a *150 N.m* couple-moment applied at shown. The beam-plate system is supported by a pin in a slot at *B* and by a pin support at *C*. Determine the reactions at *B* and *C*.



S2-311 A plate that is welded to a beam has a *50 N* and a *40 N* load applied at *D*. The beam has a *150 N.m* couple-moment applied at shown. The beam-plate system is supported by a pin in a slot at *B*, a pin in a slot at *E* and by a roller support at *C*. Determine the reactions at *B* and *C*.



S2-312 The “Balancing Rock”, St. Mary's Bay on Long Island, Nova Scotia is *9 m* high and *1 m* wide and is sitting on the rock ledge overlooking St. Mary’s Bay The rock is basalt and weighs approximately *200 kN*. If we approximate the rock as a cylinder shown in the figure, estimate the wind force, *w* that will cause the rock to topple over.



S2-313 Figures (a) and (b) are Free Body Diagrams (FBDs) of a straight and a bent bar respectively. $\boldsymbol{F_A}$ is applied at end *A* and $\boldsymbol{F_B}$ is applied at end *B*. The senses of the forces are assumed.

If the bars are in equilibrium for both cases, prove that force vectors $\boldsymbol{F_A}$ and $\boldsymbol{F_B}$ will be equal in magnitude but opposite in sense and that the line-of-action of $\boldsymbol{F_A}$ and $\boldsymbol{F_B}$ will be along the line joining *A* and *B*. (The *x'* and *y'* coordinate system are oriented so that the *x'* axes is parallel to *AB*.)

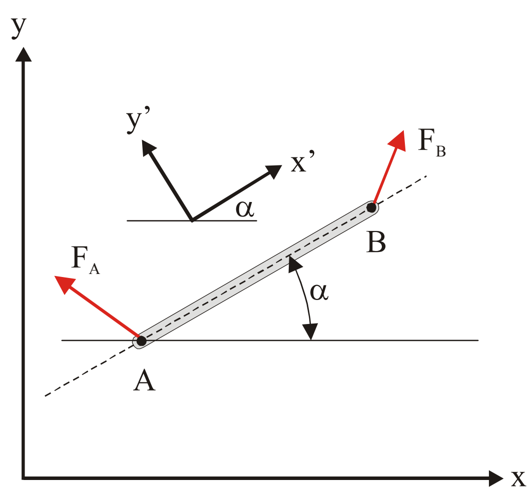


Figure (a)

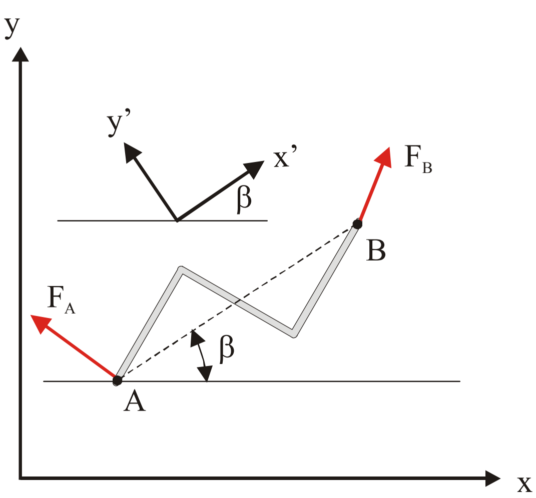
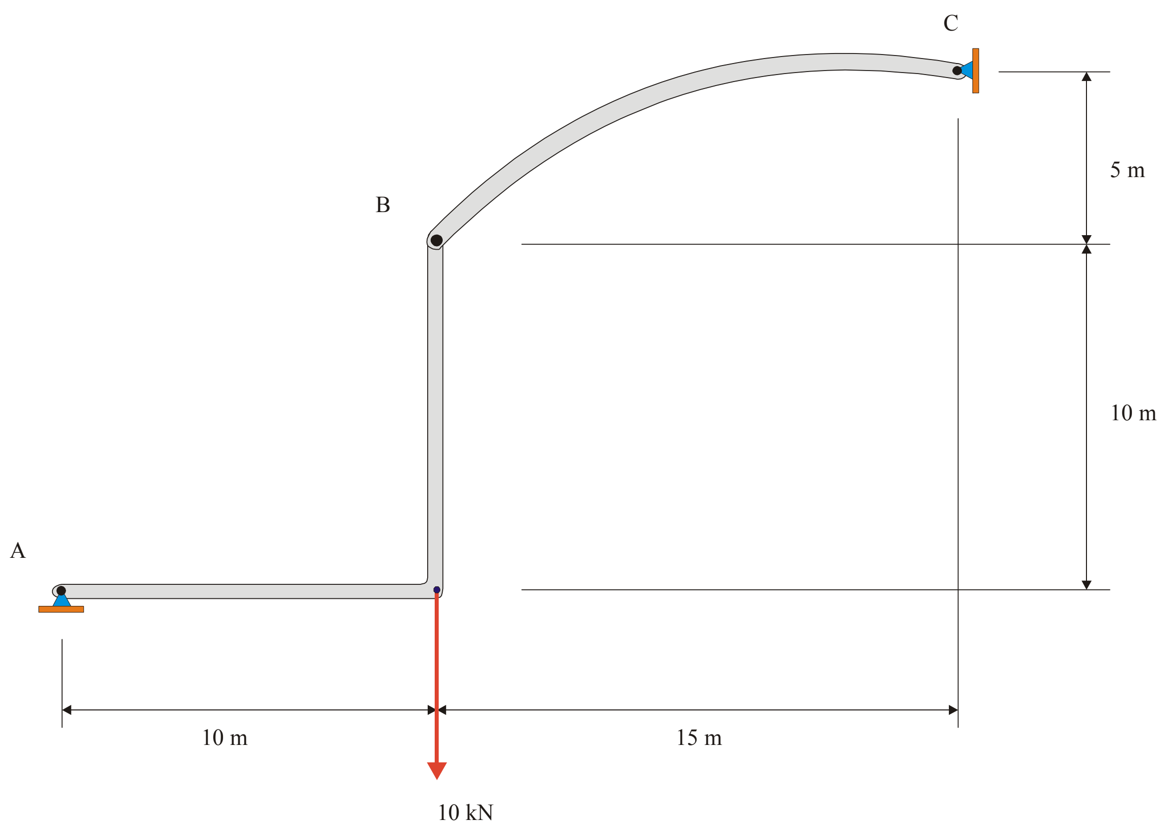


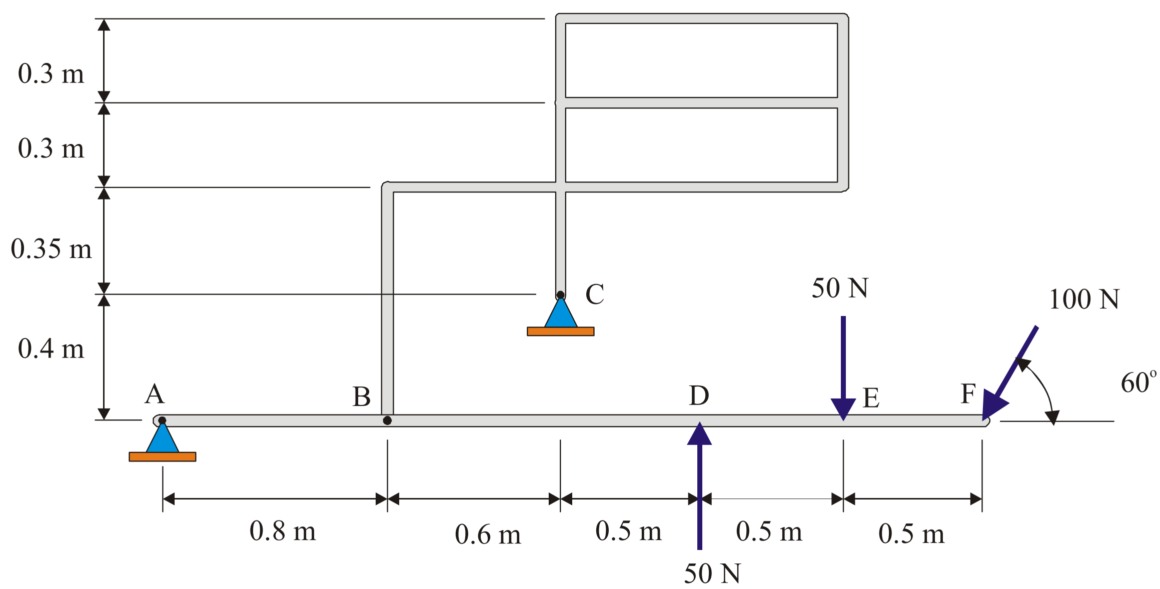
Figure (b)

S2-314 Determine the reactions at supports *A* and *C*.

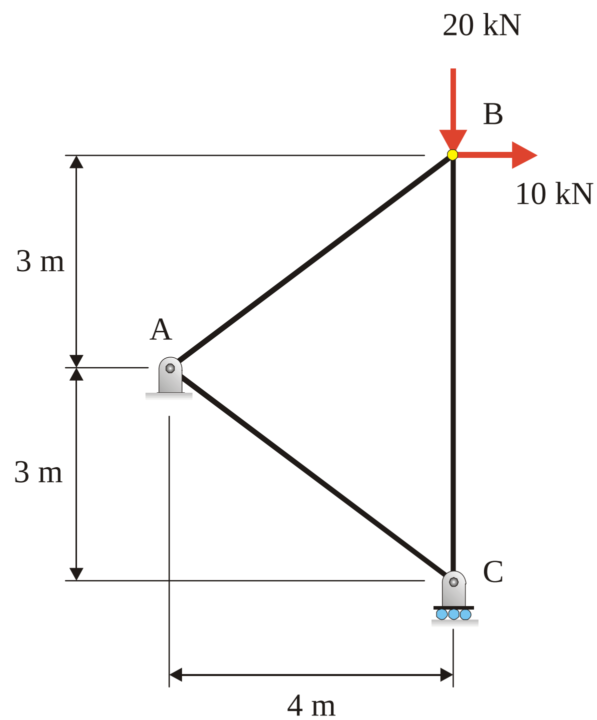


S2-315 Member *ABDEF* has a pin support at *A* and has three forces applied to it at *D*, *E* and *F*. Member *BC* has a pin support at *C* and is connected to *ABDEF* by a pin at *B*. Determine:

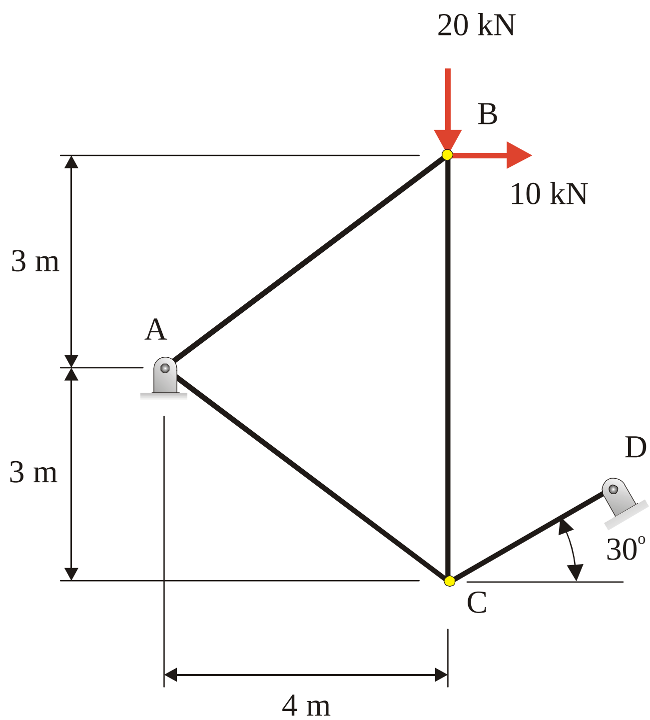
a) The reactions at *A* and *C*, and
b) The force exerted by member *BC* on member *ABDEF*.



S2-401 Determine the forces in each member of the truss shown below. State whether the member is in tension or compression.



S2-402 Determine the forces in each member of the truss shown below and state whether the member is in tension or compression.



Problem 23

S2-403 A *30 kN* load is suspended from the end of a stadium truss as shown in the Figure.
Determine:

(a) The tension in cable *AB* and the reaction at pin support *I*, and

(b) The force in each member of the truss and state whether the member is in tension or compression.

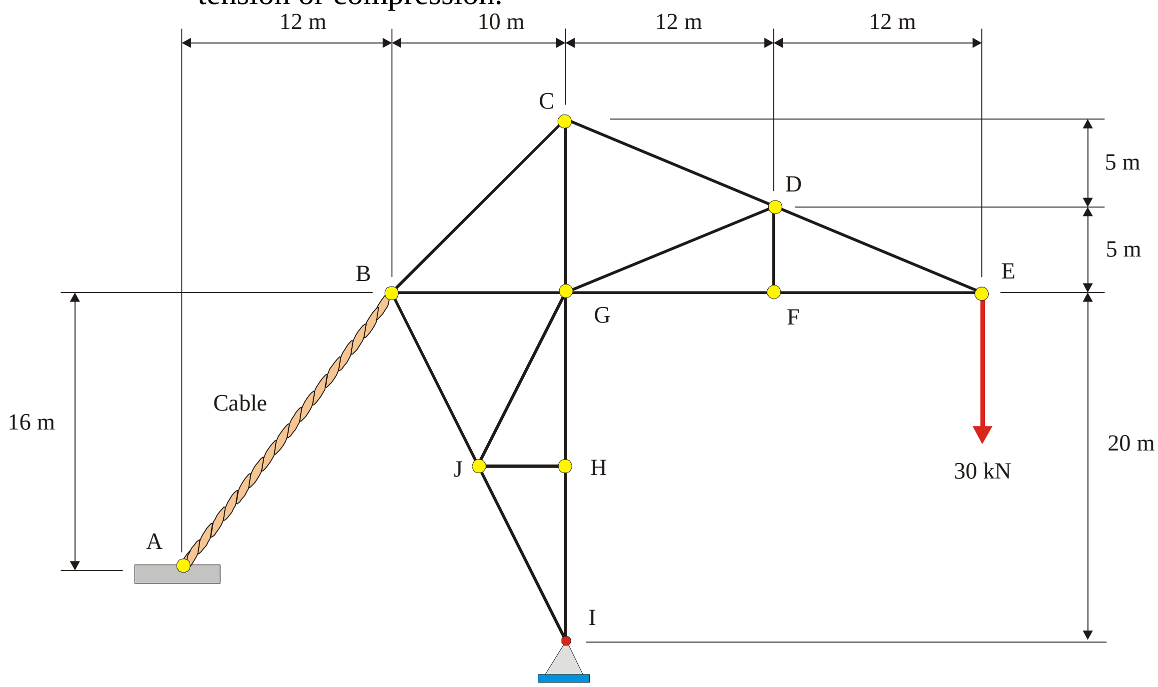
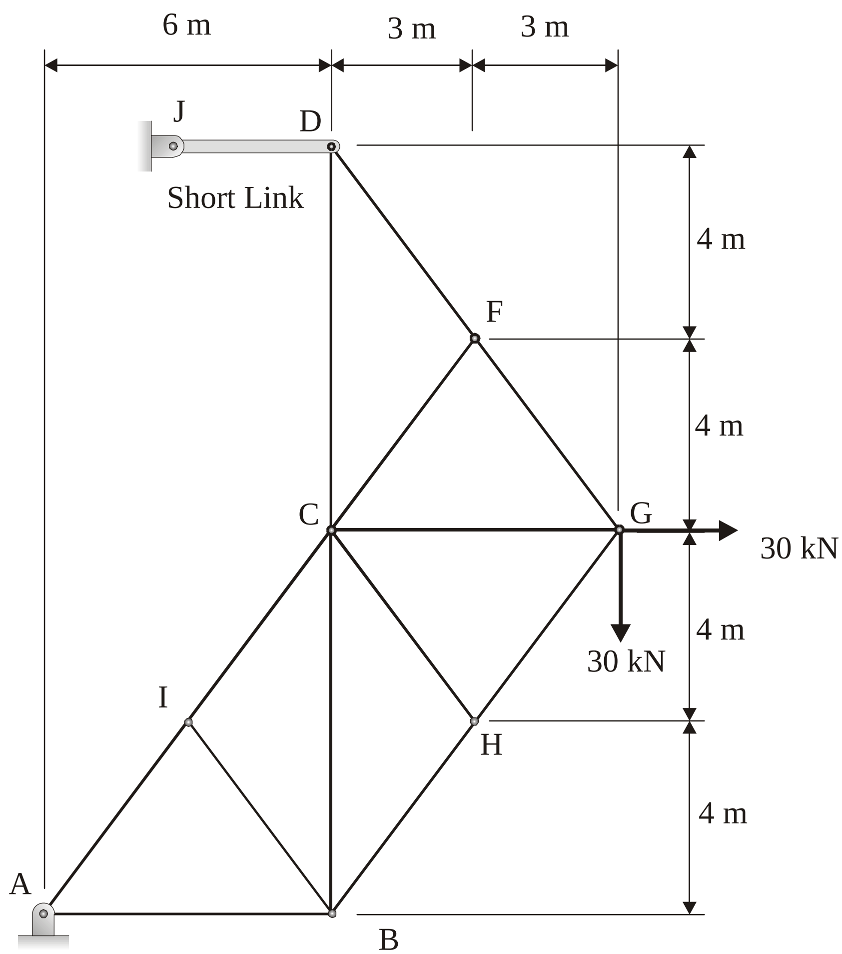


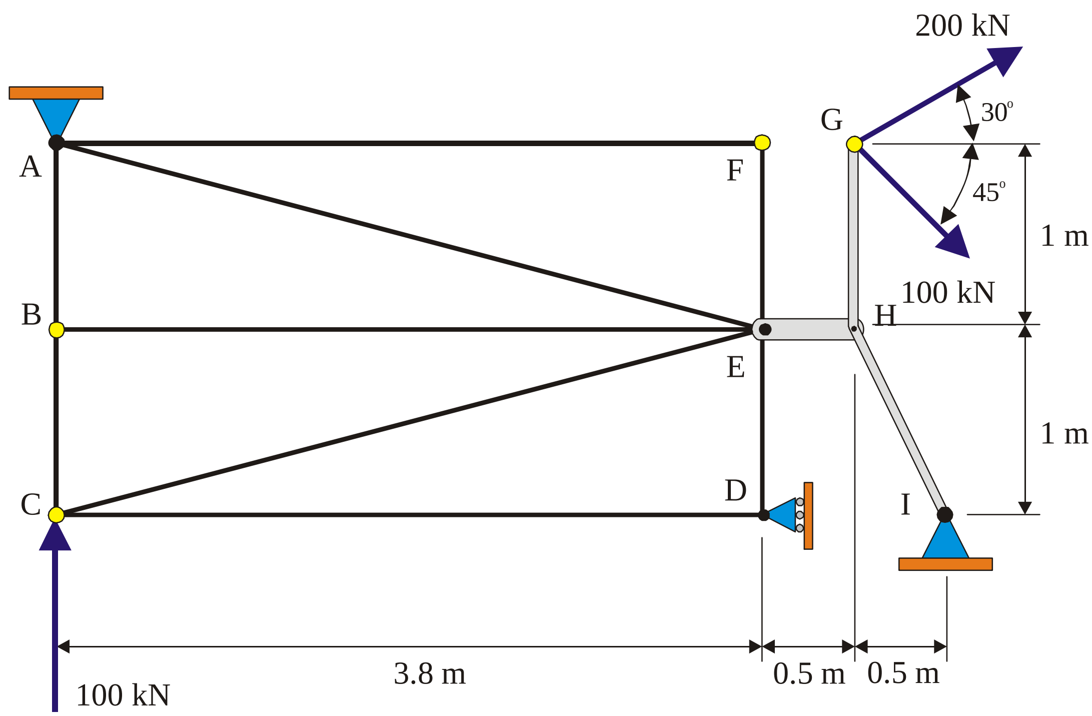
Figure (a)

S2-404 The truss shown in Figure 1(a)is supported by a pin support at *A* and by a short link *JD*. A *30 kN* horizontal load and a 30 kN vertical load are applied at joint *G*. Determine the forces in all members of the truss and state or indicate whether they are in tension or compression..

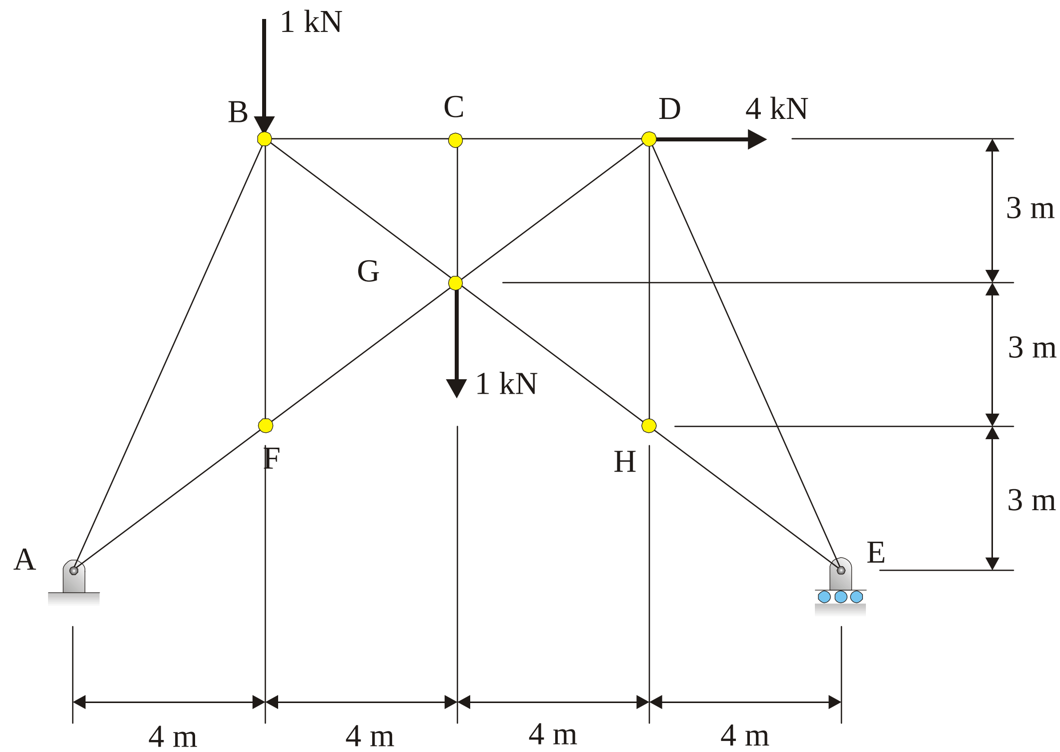


S2-405 A truss has a pin support at *A* and a roller support at *D*.The lever *GHI* with a pin support at *I* is attached by a short link *EH* to the truss.

a) Calculate the external reactions at *A*, *D* and *I*.
b) Determine the force in each member of the truss and state whether it is in tension, compression or a zero force member.



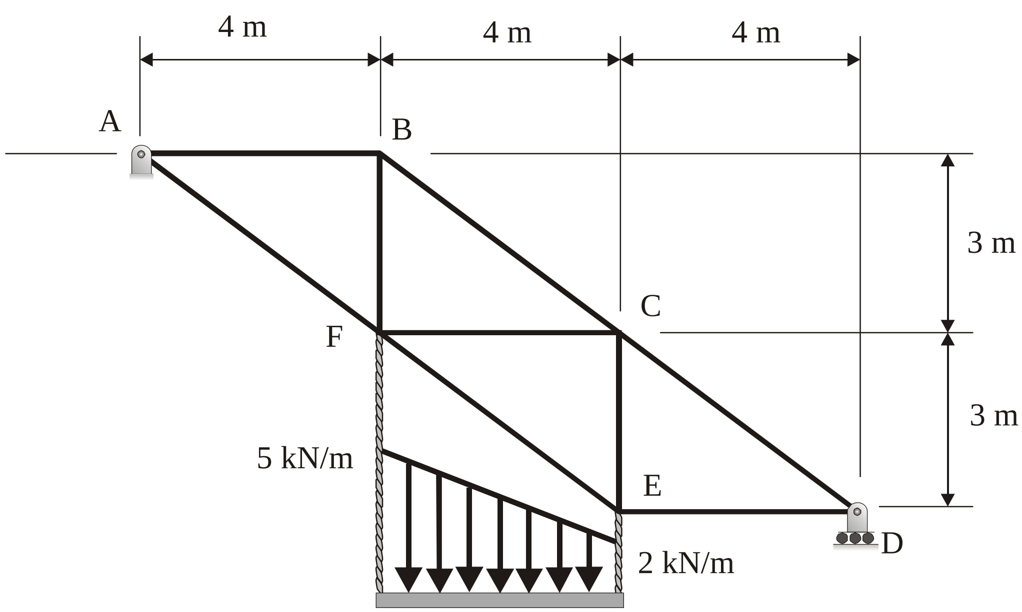
S2-406 Determine the force on each member of the truss shown in the figure and indicate whether the member is in tension or compression.



S2-407 A simple truss shown in Figure A below is supported by a pin support at *A* and by a roller support at *D*. A beam carrying a distributed load is suspended from joints *F* and *E* of the truss.

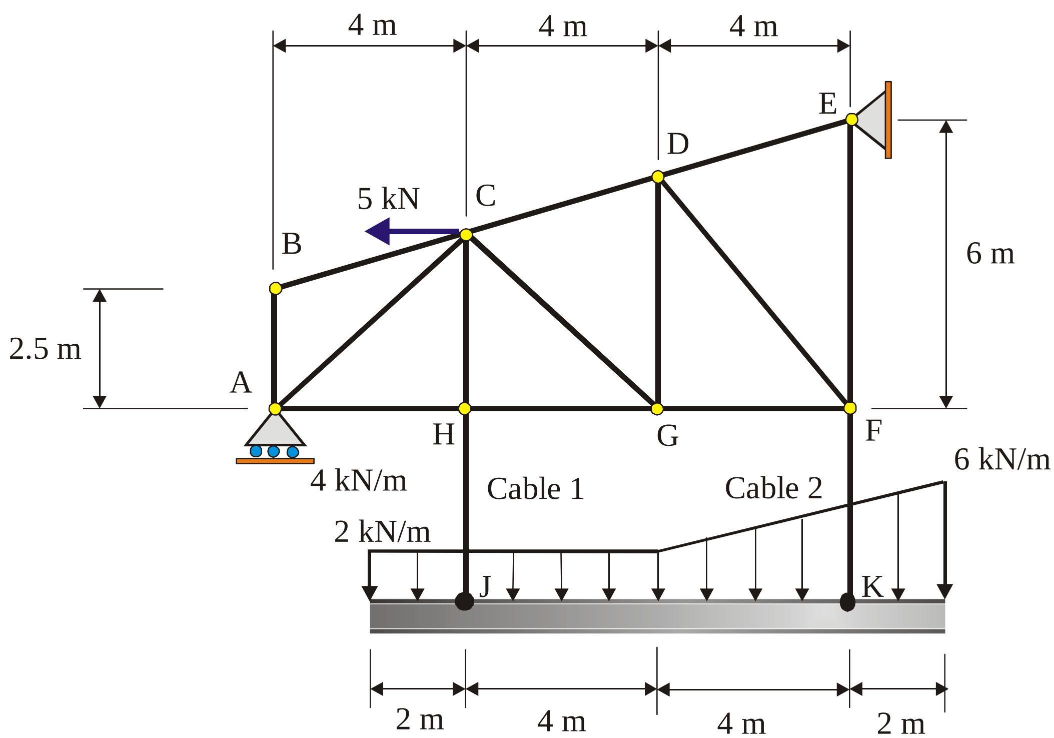
Determine:

a) The force exerted by the cables attached to the truss at *F* and at *E*,
b) The reactions at supports *A* and *D*, and
c) The force in each member of the truss and state whether it is in tension or compression.



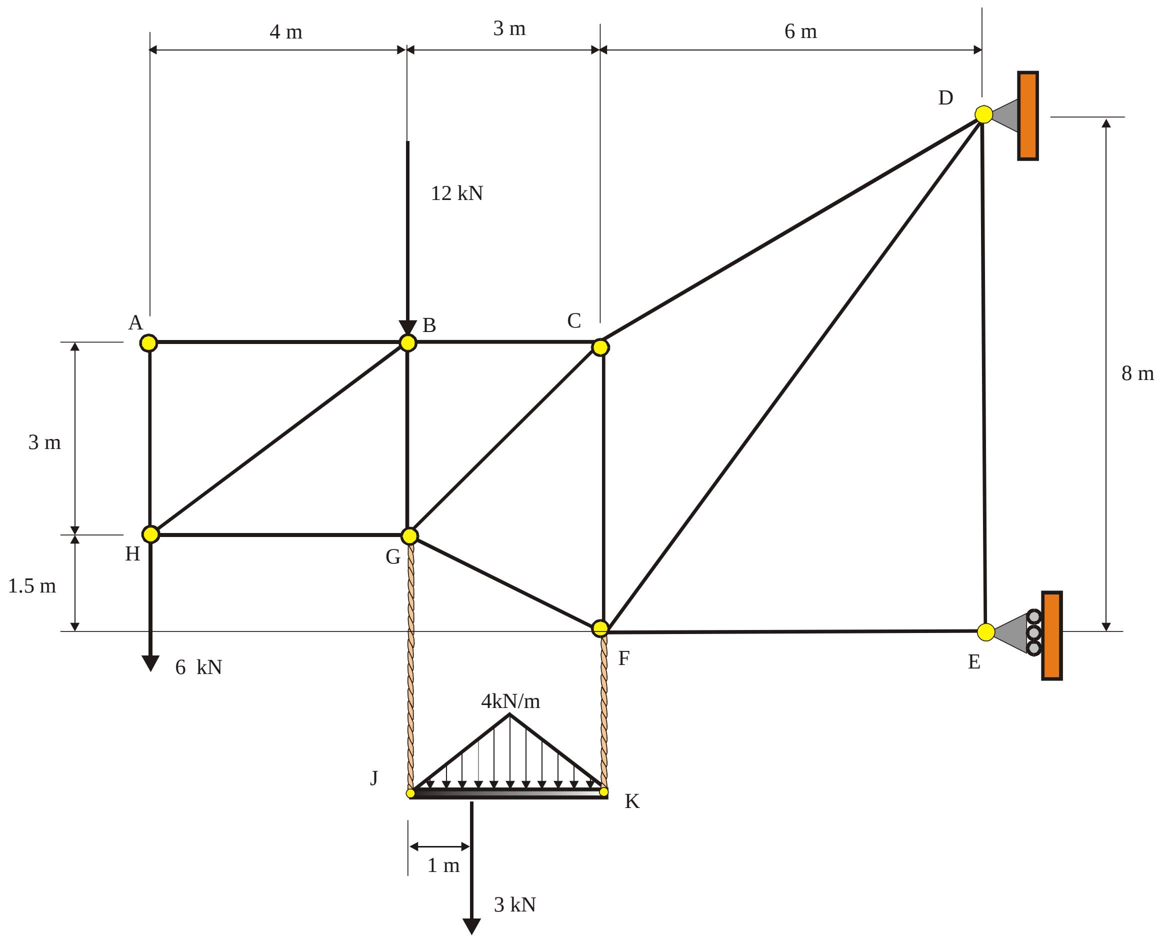
S2-408 The truss shown in the figure below has a beam suspended from two *(2)* cables. The beam supports the distributed load indicated. The truss has a pin support at *E* and a roller support at *A* and has a *5 kN* force applied at joint *C*. Determine:

a) The tension in *Cable 1 (HJ)* and *Cable 2(FK)*,
b) The reactions at *A* and *E*, and
c) The force in each member of the truss and state whether it is in tension or compression.



S2-409 A simple truss has a hinge (pin) support at *D* and a roller support at *E*. The beam *JK* is hung from the truss by cables attached at points *G* and *F*. The beam supports the distributed load shown and a point load of *8 kN*. The truss also supports 10 kN and 12 kN point loads at *B* and *H* respectively. Determine:

a) The reactions at supports *D* and *E*,
b) The tensions in cables *GJ* and *FK*, and
c) The force in each member of the truss and state whether the member is in tension, compression or a zero force member



S2-410 A satellite dish that weighs *100 kN* is attached to a beam that is supported by a simple truss by a pin support at *E* and a roller support at *C* as shown in Figure (a).

The reactions to the beam supporting the satellite dish at joints *E* and *C* of the truss **are given** in Figure (b) below (in *kN*).

a) Determine the truss support reactions at *A* and *B*.

b) Determine the force in each member of the truss and state whether it is in tension or compression.

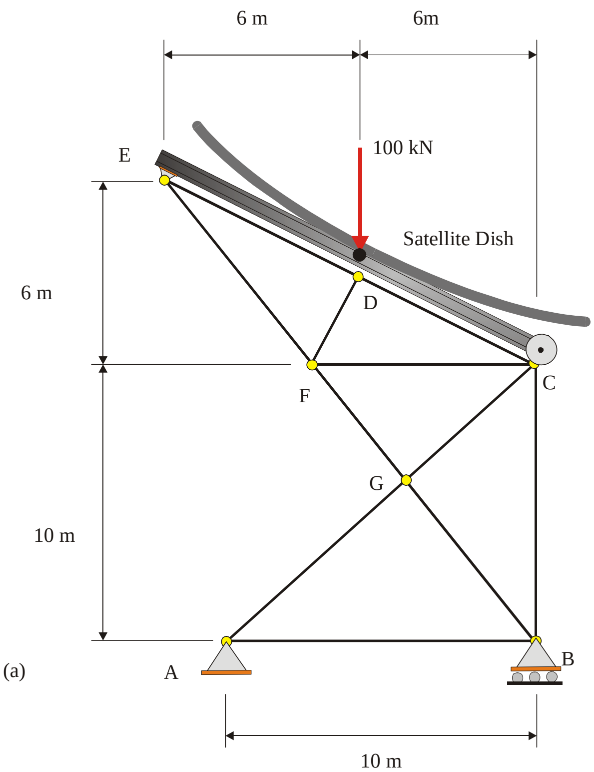


Figure (a)

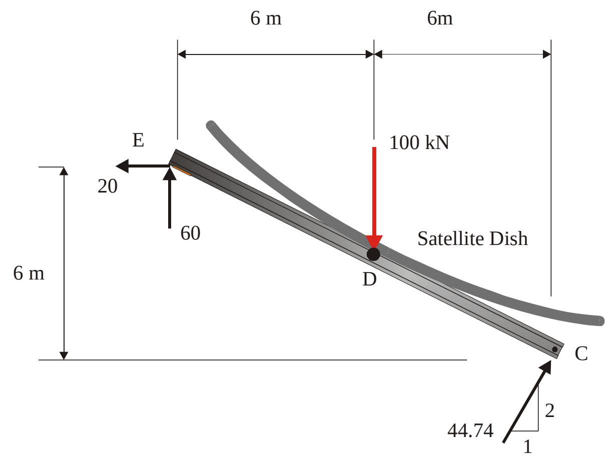


Figure (b)

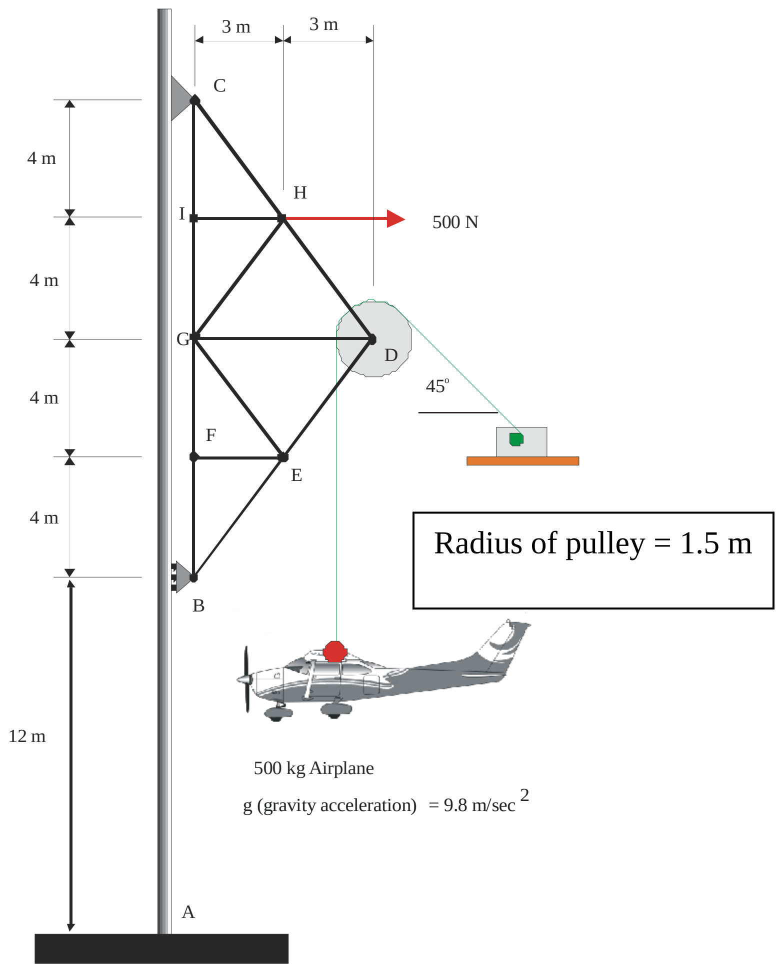
S2- 411 The pole has a fixed support at *A*. A truss is supported by the pole by a pin support at *C* and a roller support at *B.* A winch is used to lift a small airplane that has a mass of *500 kg*. The cable attached to the winch goes over a pulley that is attached to the truss at *D*. A *500 N* load is also applied to the truss at *H*.

Determine:

a) The reactions of the pulley on the truss at *D*,

b) The reactions at the fixed support at A, and

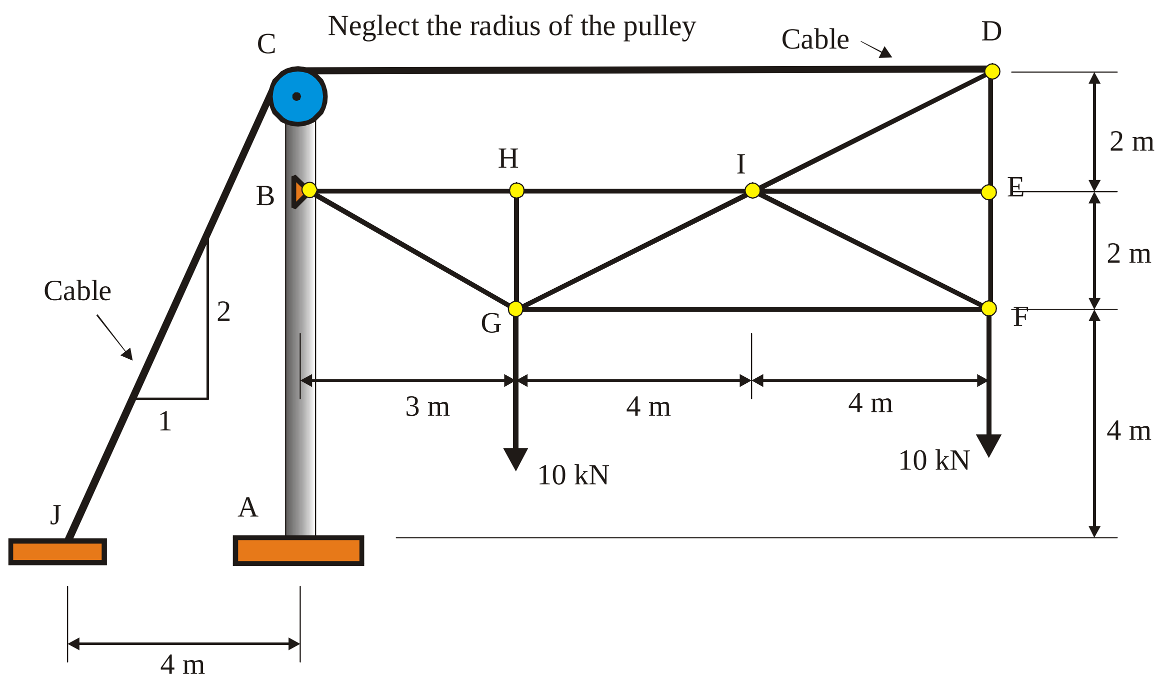
c) The force in each member of the truss and state whether it is in tension or compression.



S2-412 The truss shown in the figure below is attached to a pole by a pin support at *B*. A cable is attached to the truss at *D* and it passes over a smooth pulley attached to the pole at *C*. The cable is attached to the ground at *J*. The pole has a fixed support at *A*. The truss supports two *10 kN* loads applied at *G* and *F* respectively. (**You may neglect the radius of the pulley.**)

Determine:

d) The tension in the cable and the reaction at B,
e) The reactions at *A*, and
f) The force in each member of the truss and state whether it is in tension or compression.



S2-413 Two identical cranes are positioned on a bridge under construction in order to lift a *20 000 kg* precast concrete bridge girder into place as shown in Figure 2(a). The lift points (P1 and P2) on the girder are located as shown in Figure 2(b). The *20 000 kg* may be assumed to act at the centre of gravity of the girder *(C of G)*.

The maximum capacity of the cable anchors at *P1* and *P2* is *115 kN*.

The maximum compressive force that any member of the crane can safely carry is *150 kN* and the maximum tension force is *75 kN*.

Before the girder is lifted, you (the professional engineer) are asked by the bridge contractor to approve or not approve the lift and provide supporting calculations.

Provide calculations to support your recommendation: **(USE g = 9.8 m/sec^2). Indicate your results on one or both of the figures provided at the bottom of this page.**

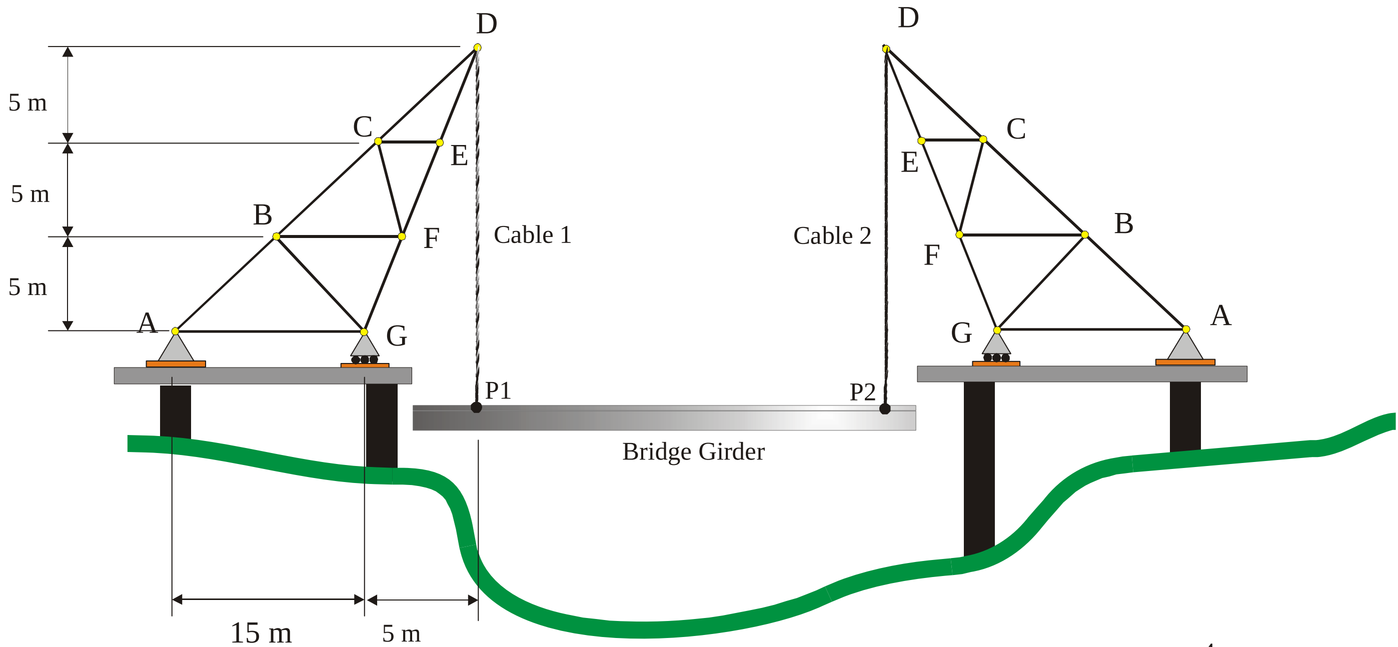


Figure 2(a)

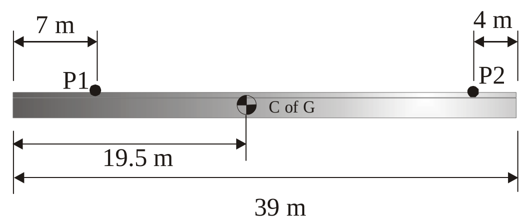
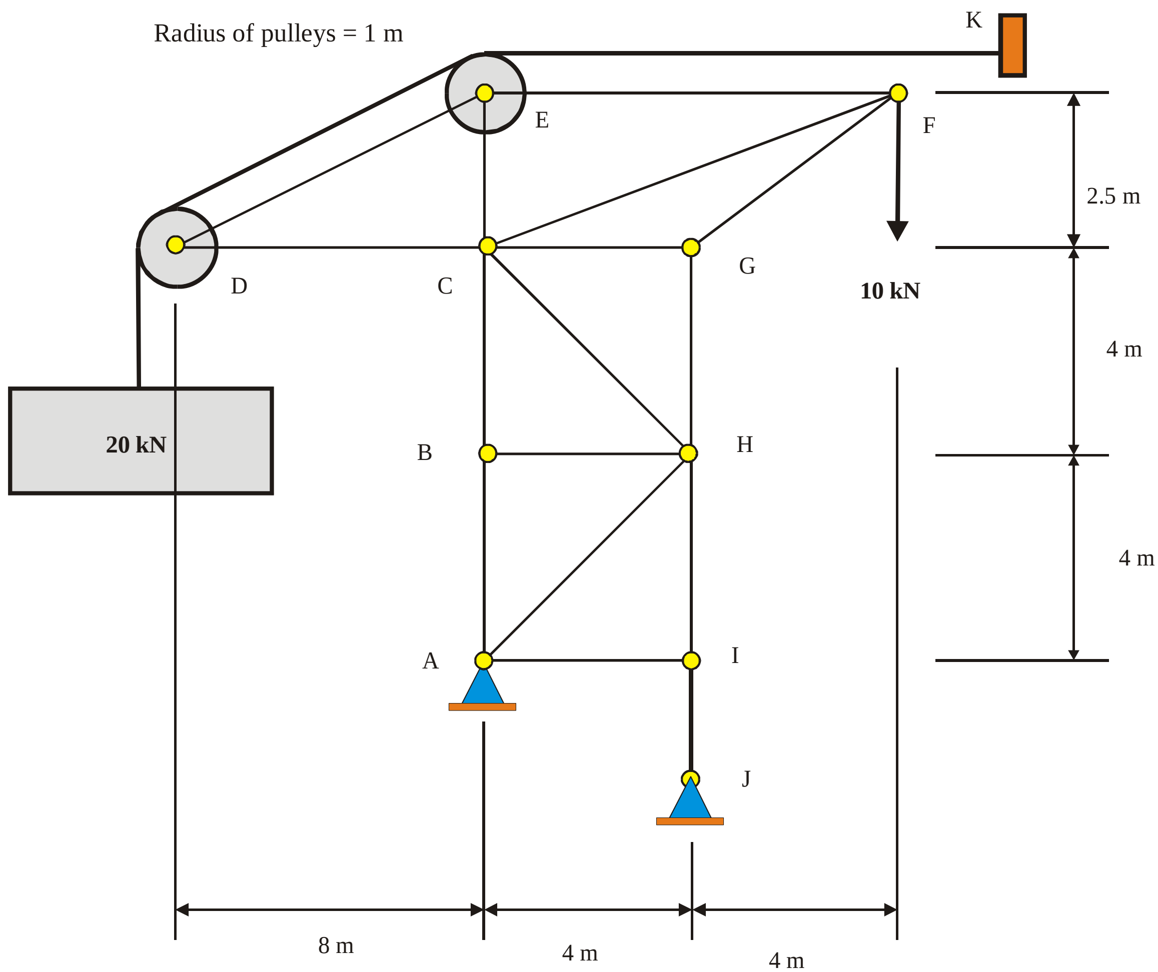


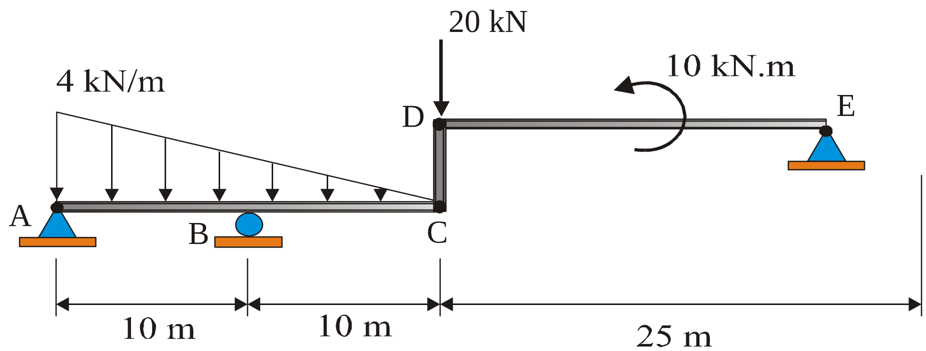
Figure 2(b)

S2-414 The truss shown has pulleys attached at Joints *D* and *E*. A *20 kN* sign is suspended from the pulleys by a cable which has an external support at *K*. Determine:

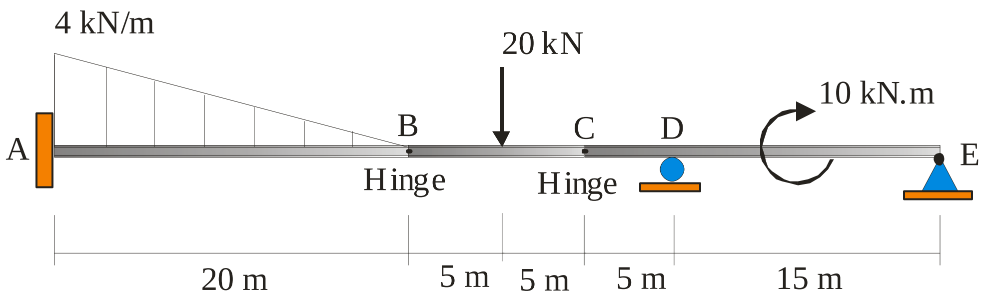
d) The reactions at *A* and *J*,
e) The forces applied to Joints *D* and *E* of the truss by the pulleys, and
f) The force in each member of the truss and state whether the member is in tension, compression or a zero force member.



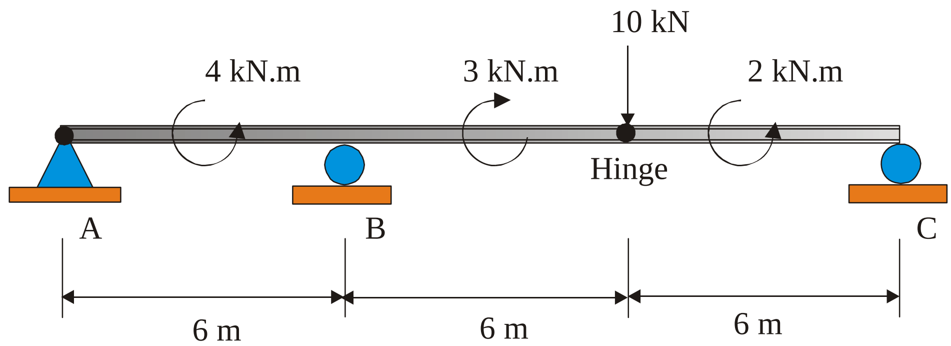
S2-415 Two beams are connected by a link by pins at *C* and *D*. External supports at *A* and *E* are pin supports. The support at *B* is a roller support. Determine the reactions at A, B and E.



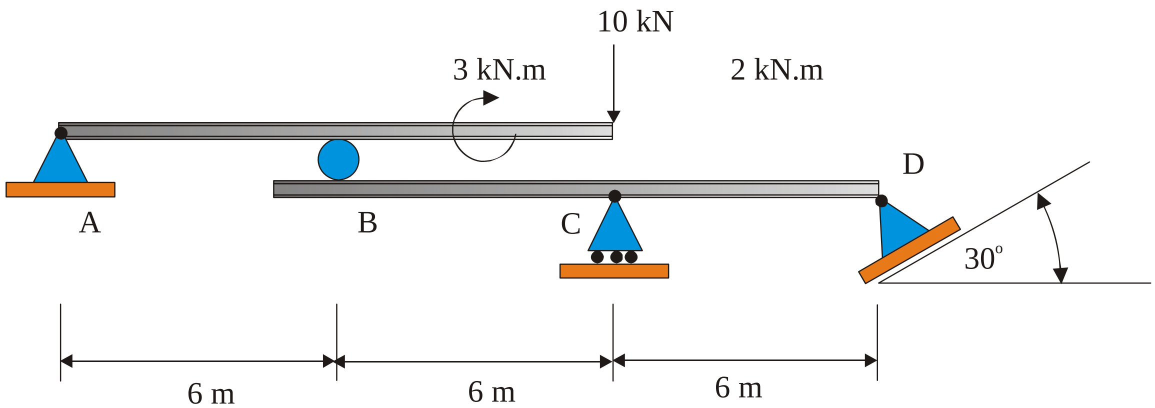
S2-416 Determine the reactions at A, D and E for the beam system shown.



S2-417 Determine the reactions at supports A, B and C for the beam shown.

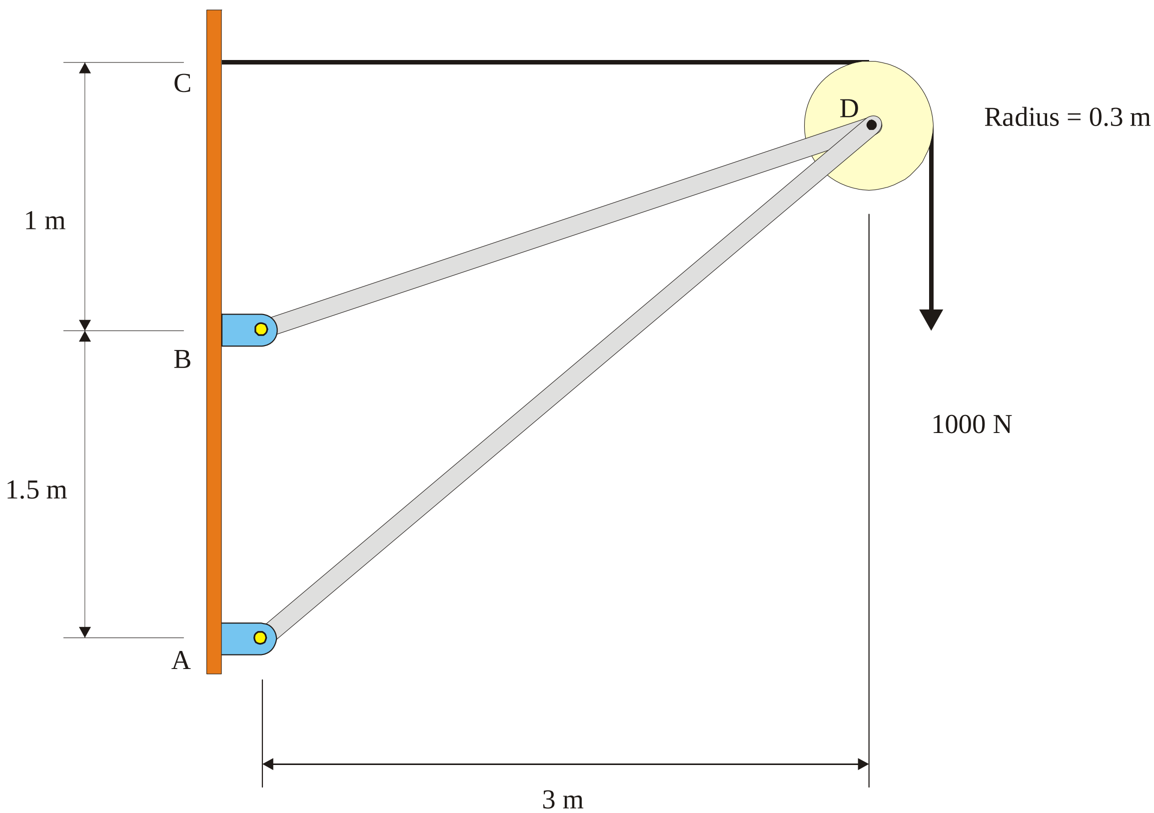


S2-418 Determine the reactions at A, B, C and D.



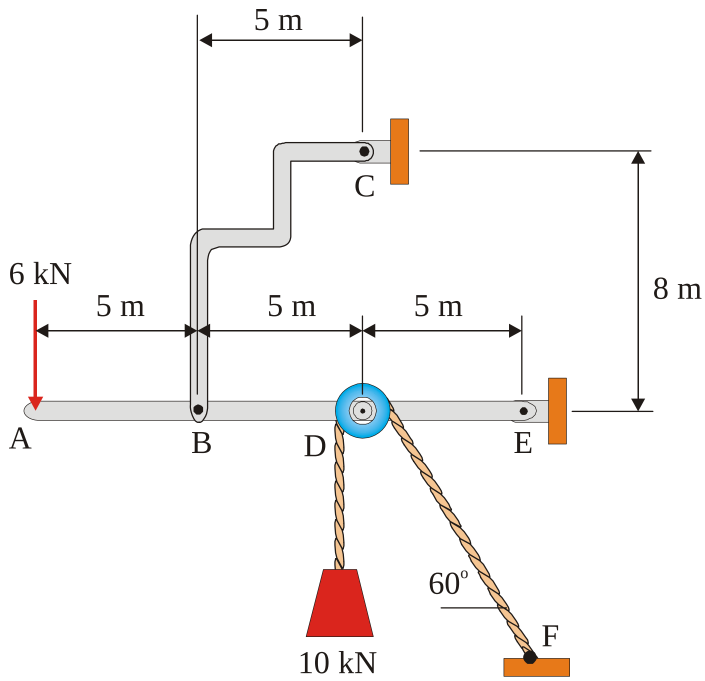
S2-419 A smooth pulley with a radius of *0.3 m* is attached to a frame consisting of members *AD* and *BD* at point *D*. A rope that is attached to the wall at *C* passes over the pulley and supports a *1000 N* load as shown in the figure.

Determine the forces in members *AD* and *BC*.

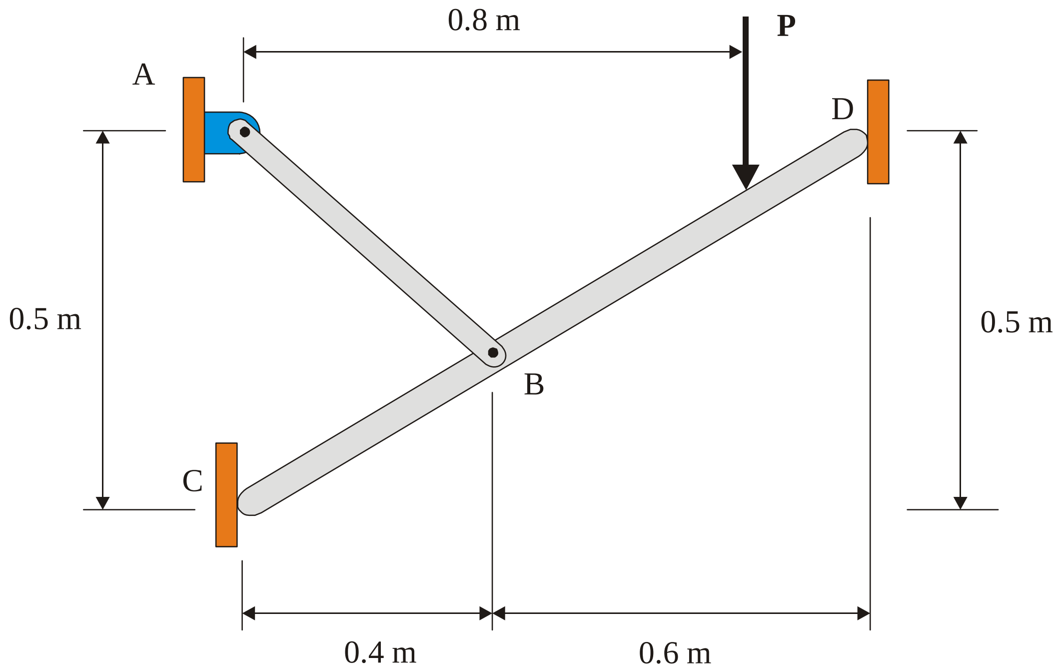


S2-420 A pulley attached is attached to the frame shown. Neglecting the radius of the pulley. Determine:

(a) The reactions at *C* and *E*, and
(b) The forces at *B* and *D* on member *ABDE*.

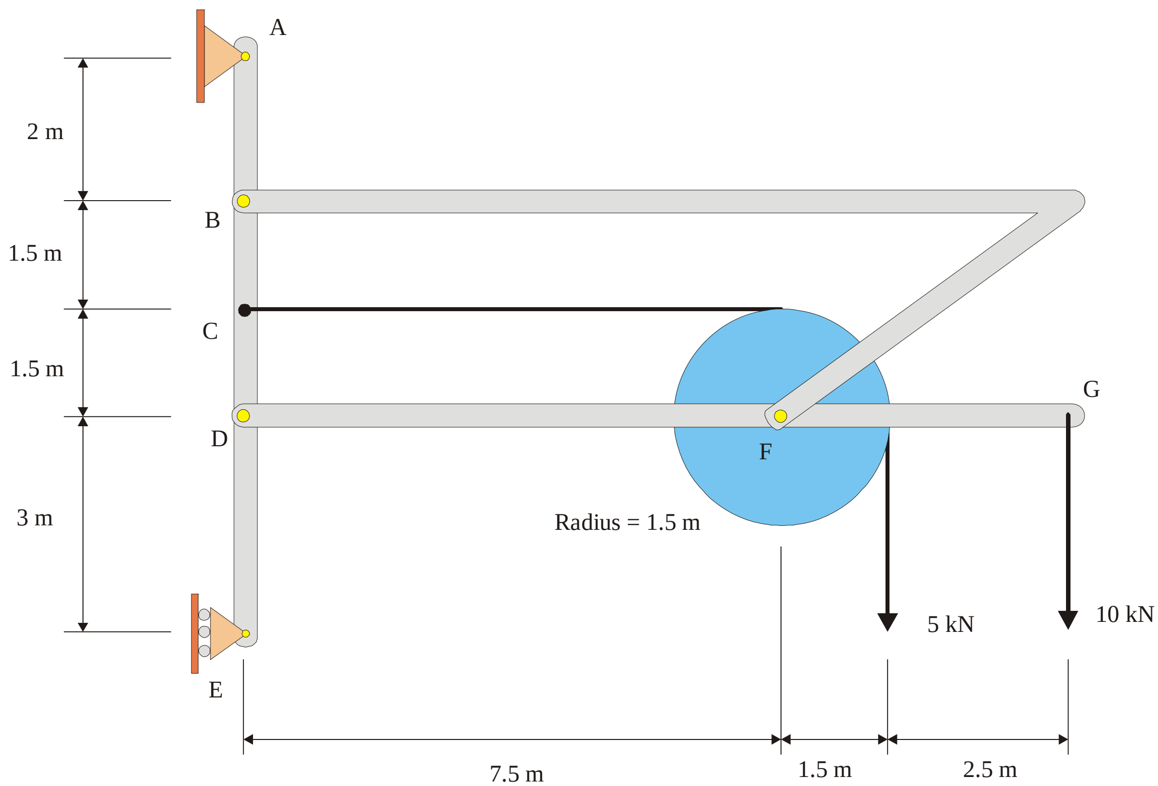


S2-421 A vertical load ***P*** of *1200 N* is applied to the member *CD* which is placed between two frictionless walls as shown in the figure. Member *CD* is pin connected at *B* to a link *AB*.
Determine all forces exerted on member *CD*.



S2-422 The frame shown in the figure has a pin support at *A* and a roller support at *E*. A single pin at *F* connects member *BF*, member *DFG* and a *1.5 m* radius pulley.
Determine:

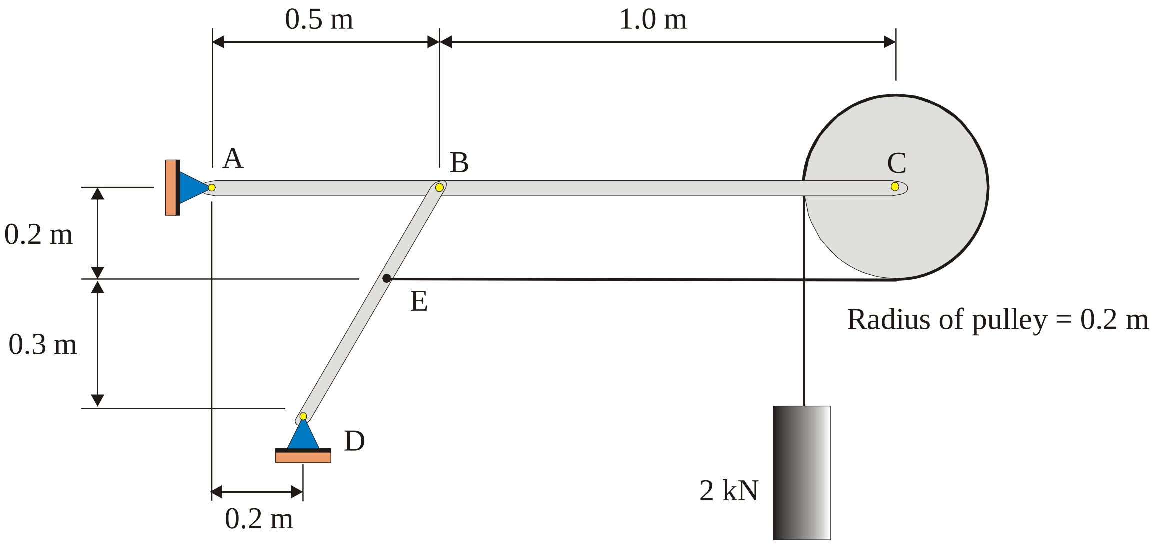
d) The reactions at supports *A* and *E*,
e) The force exerted by the pins at *B* and *D* on member *ABCDE*.
f) The force exerted by member *BF*, member *DFG* and the pulley on the pin at *F*.



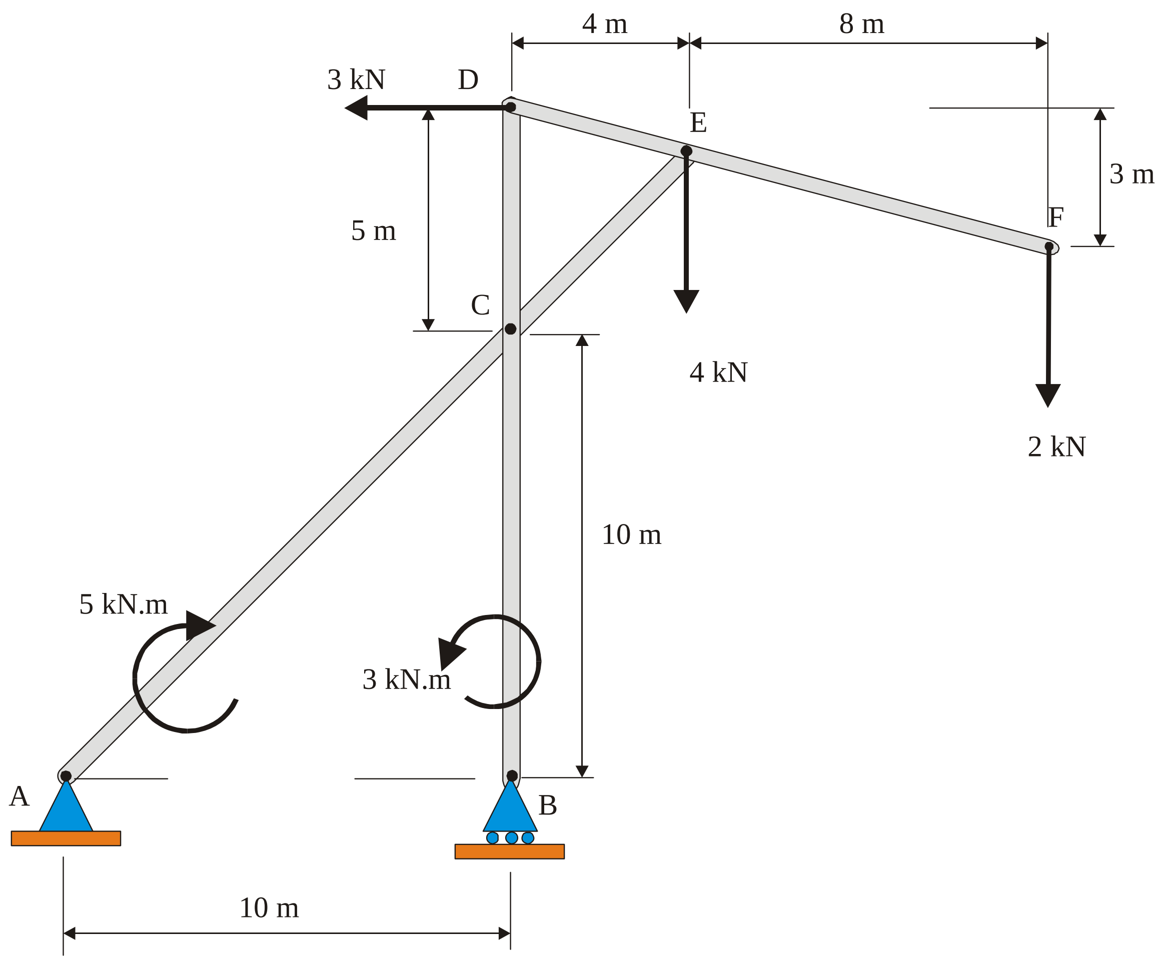
S2-423 In the frame shown, the members are pin-connected and their weights can be neglected. The cable wraps around the frictionless pulley at *C* as shown in the figure.

(a) Find the support reactions on the frame at *A* and *D*.

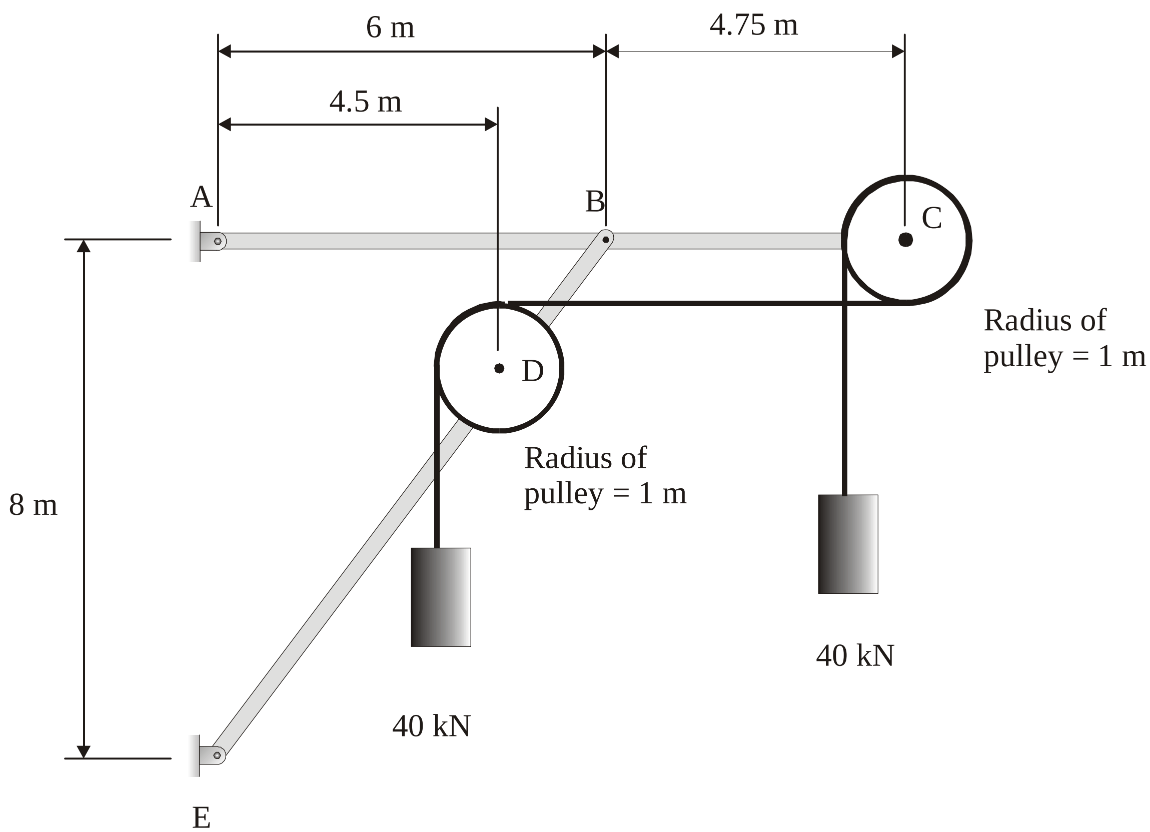
(b) Find the forces at *B* and *C* on the member *ABC*.



S2-424 Determine the forces acting on all members of the frame shown below.

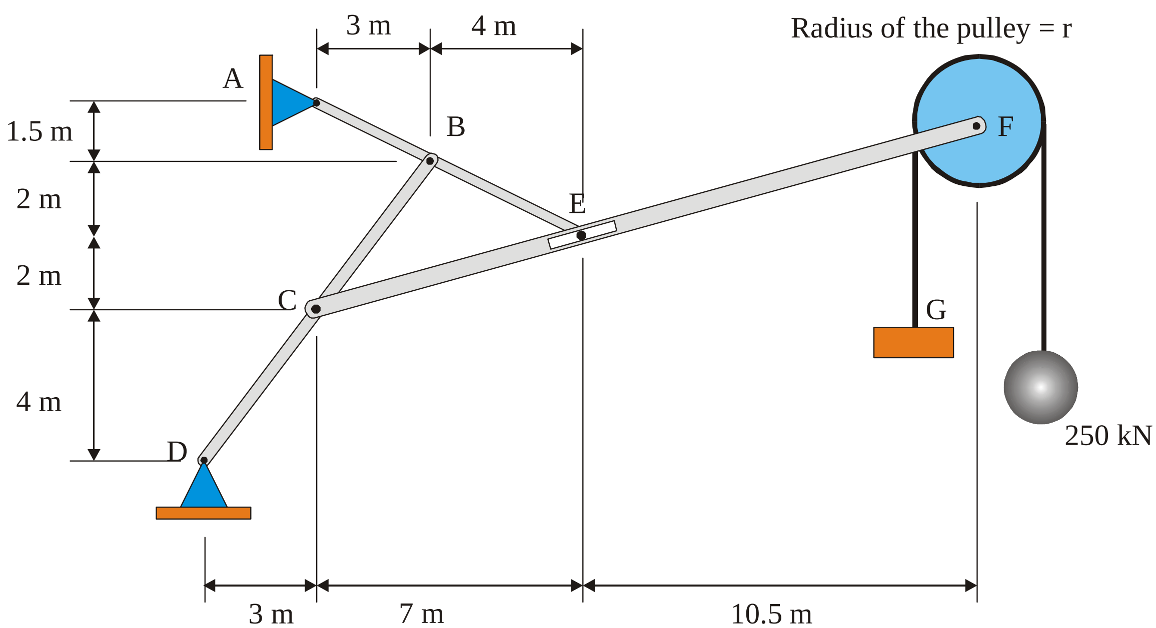


S2-425 Two *40 kN* weights are suspended from a cable that is wrapped around a simple pulley at *C* and which passes over another simple pulley at *D*. The system is in equilibrium. Determine the reactions at *A* and *E* and the horizontal and vertical components of the force at *B* on member *ABC*.



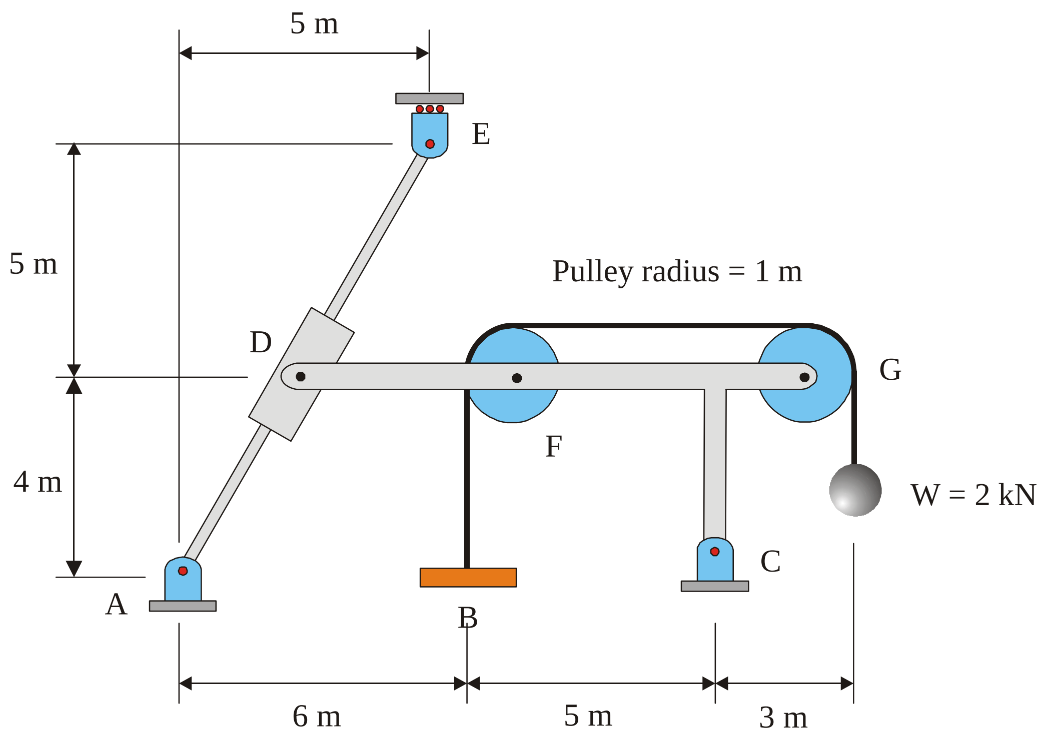
S2-426 The frame shown has pin supports at *A* and *D*.A *250 kN* weight is suspended from a cable that passes over a smooth pulley of radius, *r*, and is attached to the floor at *G*. Member *CEF* contains a slot at *E*. A pin attached to member *ABE* rests in the slot. Determine:

a) The reactions at *A* and *D*, and
b) The forces exerted on all members of the frame.



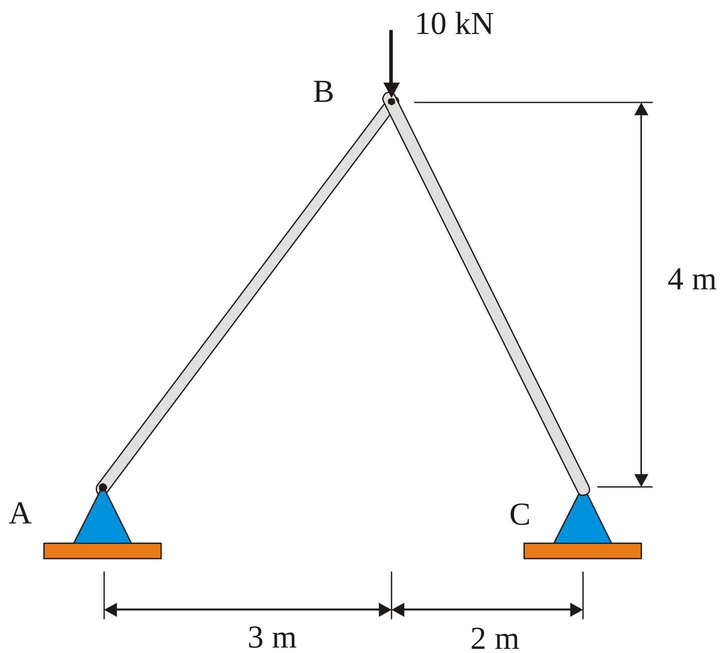
S2-427 A smooth collar can slide on the rod *AE*. Two smooth pulleys are attached to member *DC* at *F* and *G*. The cable passing over the pulleys supports a weight of *2 kN*. The supports at *A* and *C* are pin supports and the support at *E* is a roller support. Determine:

a) the reactions at *A*, *B*, *C* and *E*, and
b) the force exerted by the collar at *D* on the rod *AE*.



S2-428 The frame shown has pin supports at *A* and *C*. A *10 kN* force is applied at *B*. Determine:

a) The reactions at *A* and *C* and the force exerted at *B* on members *AB* and *AC*. When sub-structuring draw a separate FBD of the pin at *B*.
b) The reactions at *A* and *C* and the force exerted at *B* on members *AB* and *AC*. When sub-structuring in the FBDs leave the pin "attached" to member *AB*.
c) The reactions at *A* and *C* and the force exerted at *B* on members *AB* and *AC*. When sub-structuring in the FBDs leave the pin "attached" to member *AC*.

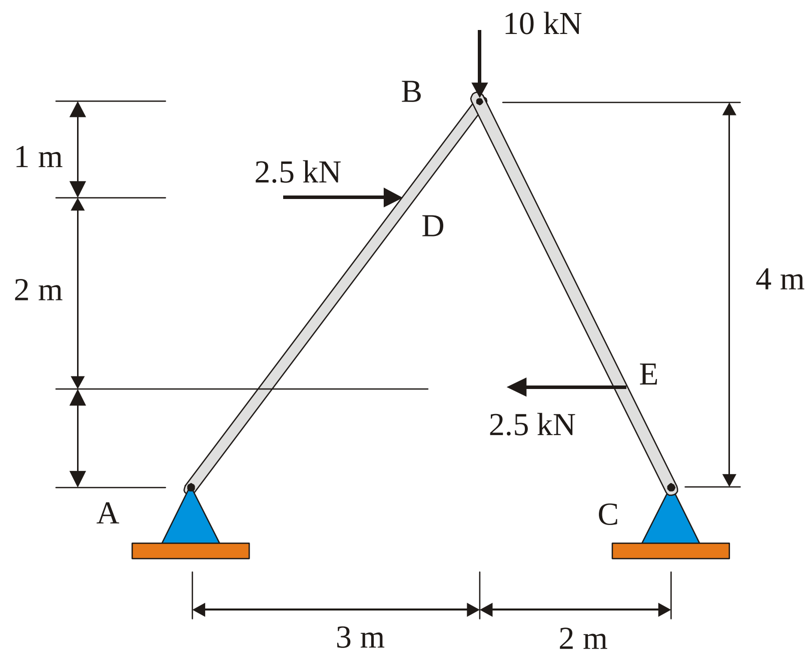


S2-429 The frame shown has pin supports at *A* and *C*. A *10 kN* force is applied at *B*. Two *2.5 kN* forces are applied at points *D* and *E*. Determine:

d) The reactions at *A* and *C* and the force exerted at *B* on members *AB* and *AC*. When sub-structuring draw a separate FBD of the pin at *B*.

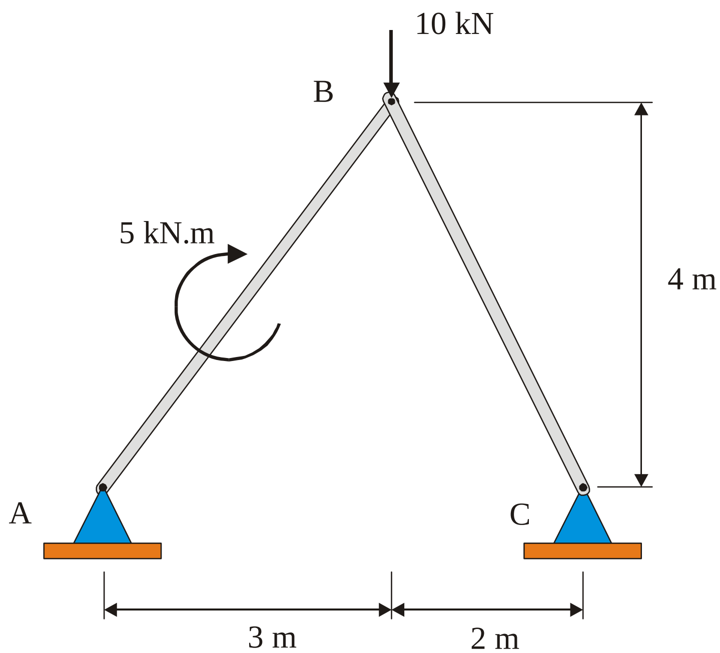
e) The reactions at *A* and *C* and the force exerted at *B* on members *AB* and *AC*. When sub-structuring in the FBDs leave the pin "attached" to member *AB*.

f) The reactions at *A* and *C* and the force exerted at *B* on members *AB* and *AC*. When sub-structuring in the FBDs leave the pin "attached" to member *AC*.



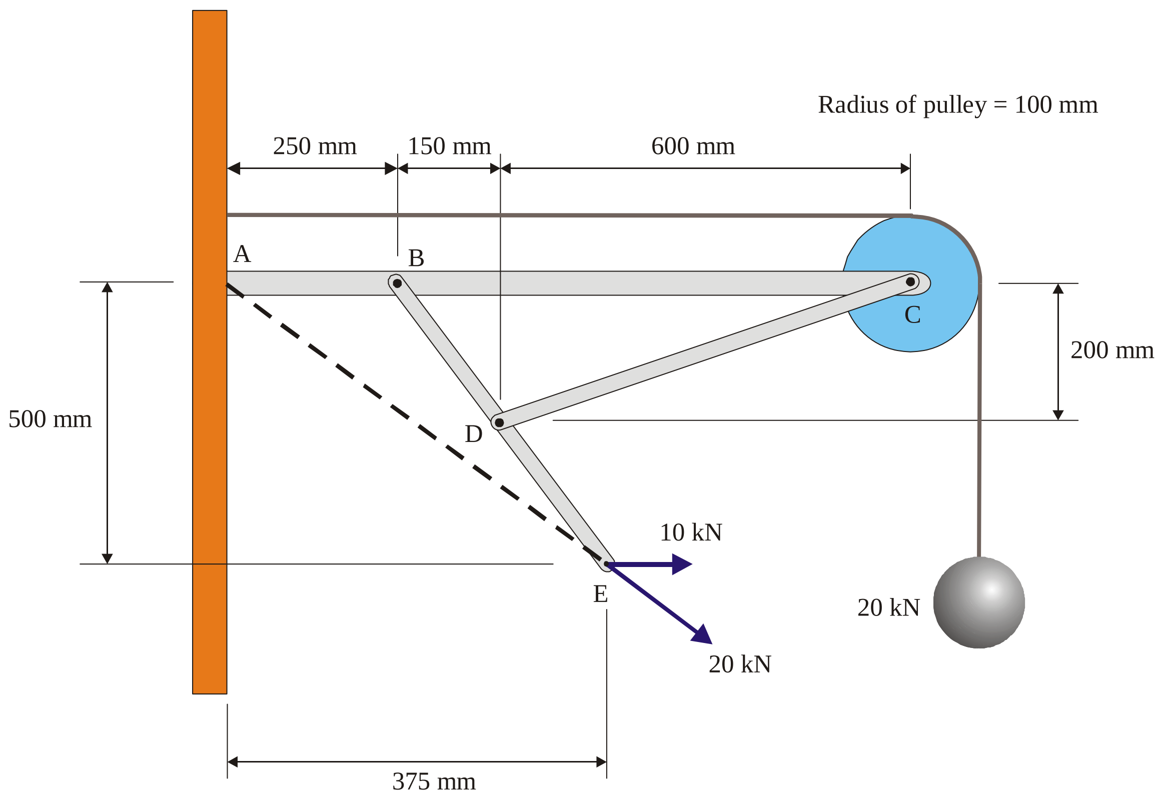
S2-430 The frame shown has pin supports at *A* and *C*. A *10 kN* force is applied at *B*. A clockwise couple moment of *5 kN. m* acts on member *AB*. Determine:

g) The reactions at *A* and *C* and the force exerted at *B* on members *AB* and *AC*. When sub-structuring draw a separate FBD of the pin at *B*.
h) The reactions at *A* and *C* and the force exerted at *B* on members *AB* and *AC*. When sub-structuring in the FBDs leave the pin "attached" to member *AB*.
i) The reactions at *A* and *C* and the force exerted at *B* on members *AB* and *AC*. When sub-structuring in the FBDs leave the pin "attached" to member *AC*.



S2-431 A frame pulley arrangement has a fixed support at *A*. The cable passing over the pulley is attached to the wall supports a *20 kN* weight. The pulley has a radius of *100 mm*. A *10 kN* force and a *20 kN* force are applied to the frame at *E*. The *10 kN* force is horizontal. The line-of- action of the *20 kN* force passes through *A*. Determine:

a) The reactions at the fixed support *A*.
b) The forces acting on all members of the frame.

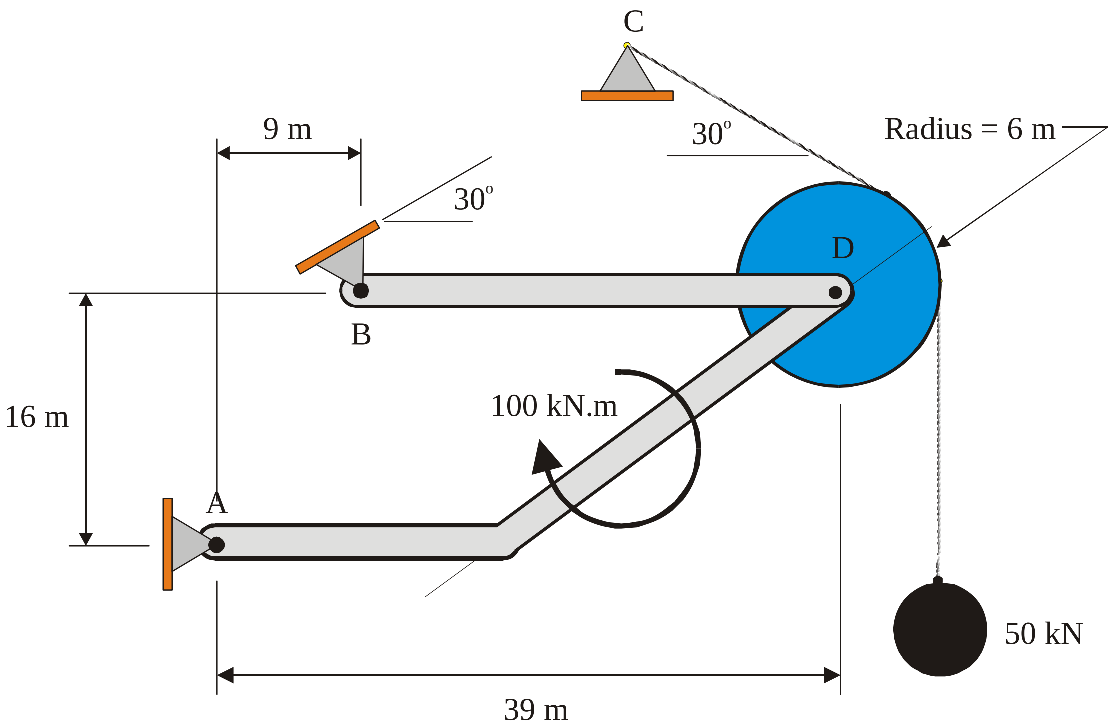


S2-432 The frame shown in Figure 3 supports a *50 kN* weight suspended from a cable that passes over a smooth pulley and attached to an external support at *C*. A *100 kN.m* couple moment is applied to bent member *AD*. Determine:

a) the reactions at pin supports *A* and *B*,

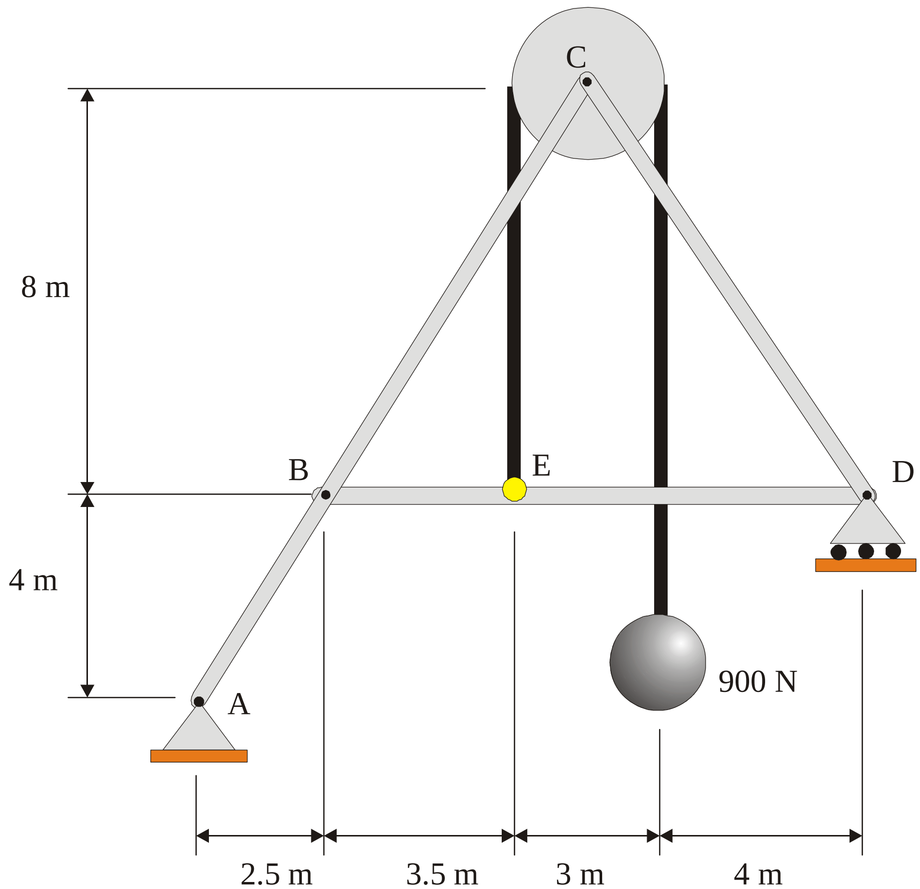
b) the force exerted at *D* on the member *BD* and,

c) the force exerted at *D* on the member *AD*.



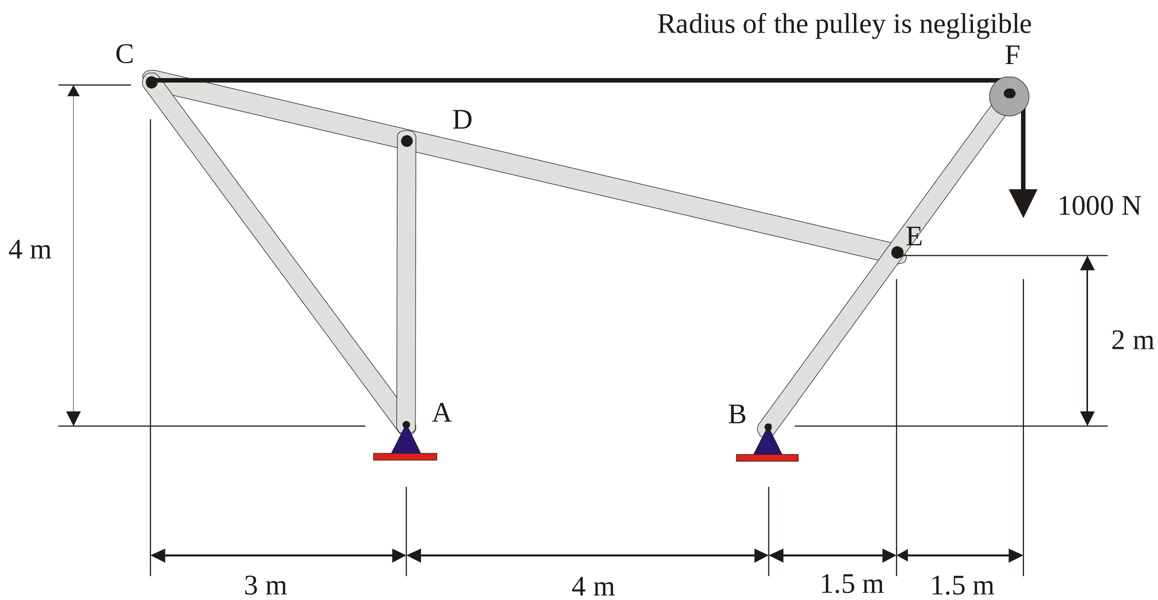
S2-433 A *900 N* weight is suspended from a cable that passes over a frictionless pulley of radius *1.5 m* and is attached back to a frame at *E*. The frame has a pin support at *A* and a roller support at *D*.

a) Determine the reactions at supports *A* and *D*.
b) Determine all forces exerted on members *ABC*, *BED* and *CD*.



S2-434 The frame shown in the figure below supports a *1000 N* load suspended from a pulley (neglect the radius of the pulley) and has pin supports at *A* and *B*.

a) Identify any two force members in the frame.
b) Determine the reactions at pin supports *A* and *B*.
c) Determine the forces acting on **ALL** members of the frame.



S2-435 For the frame shown in the figure a smooth pulley attached to the frame rests on a cable at *B*.

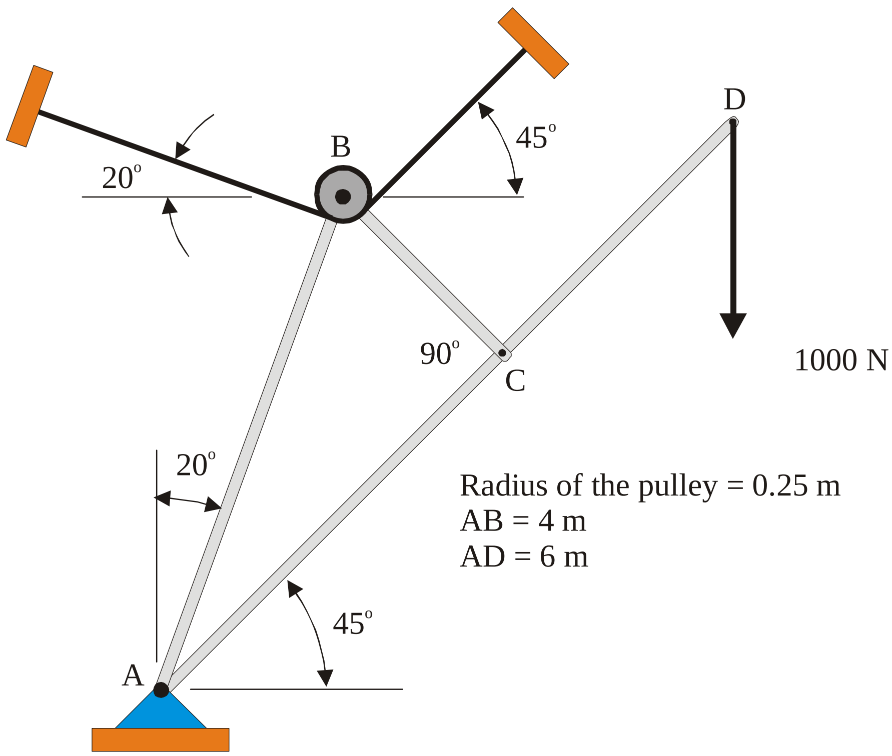
(You may ignore the radius of the pulley.)

Determine:

a) State which members of the frame are *2-force* members,

b) The tension in the support cable and the reaction at the pin support at *A*, and

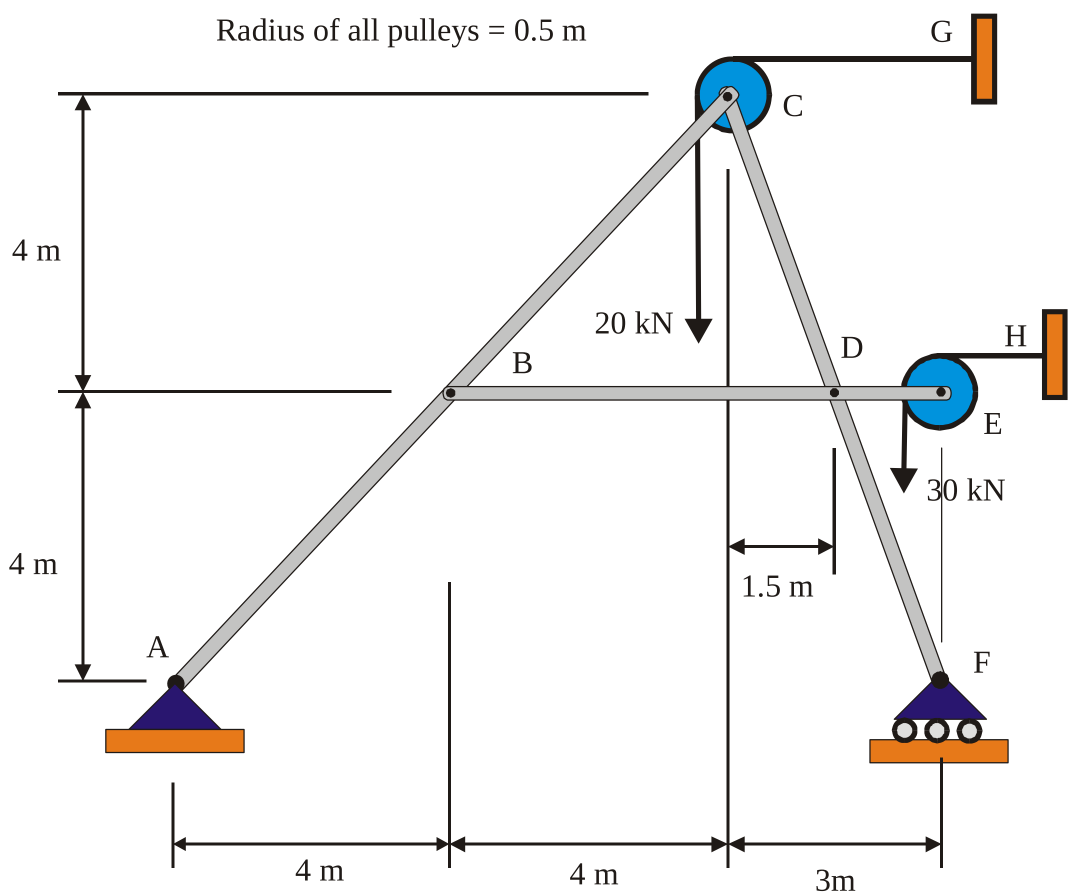
c) The force in members *ACD*, *AB* and *BC*.



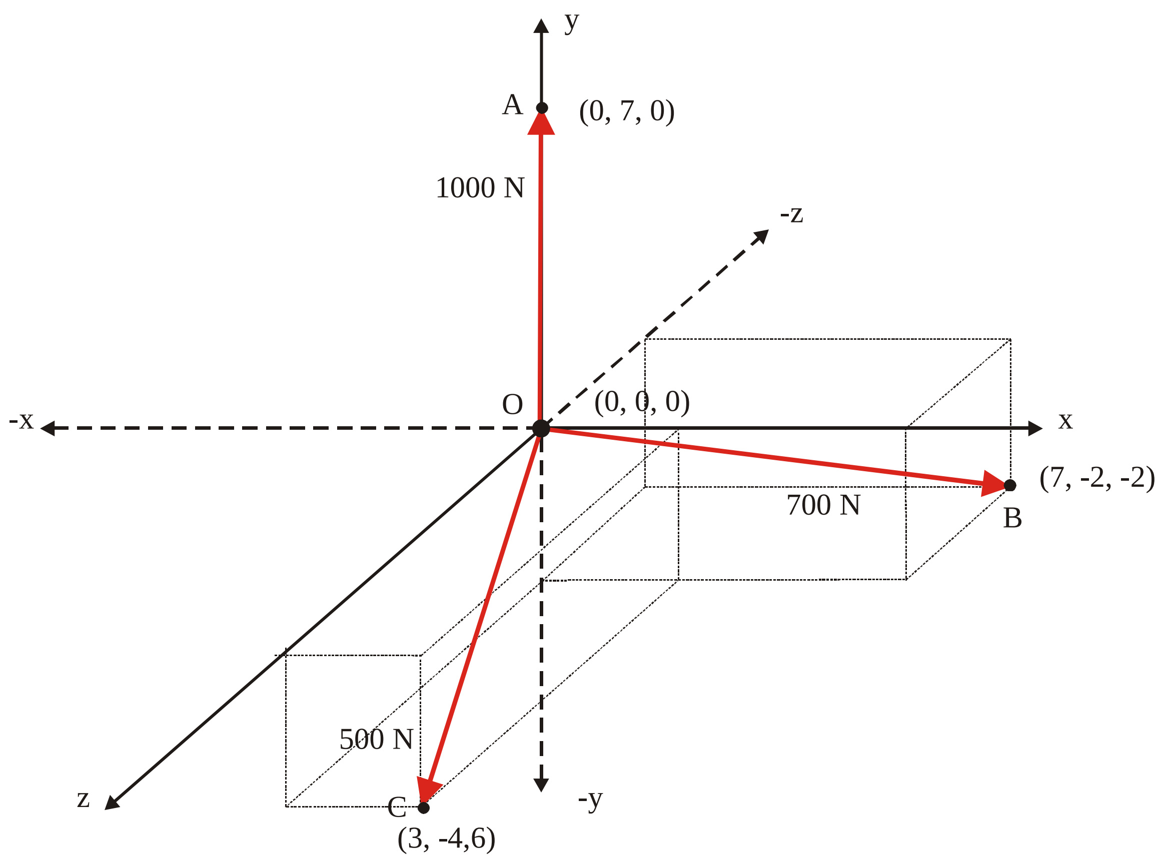
S2-436 The frame shown has three members (*Member ABC, Member BDE and Member CDF*) pinned together at points *B*, *C* and *D*. Smooth pulleys having a radius of *0.5 m* are attached to the frame at *C* and *E*. Cables supporting a *20 kN* load and a *30 kN* load are attached back to external supports at *G* and *H*. The frame has a pin support at *A* and a roller support at *F*.

Determine:

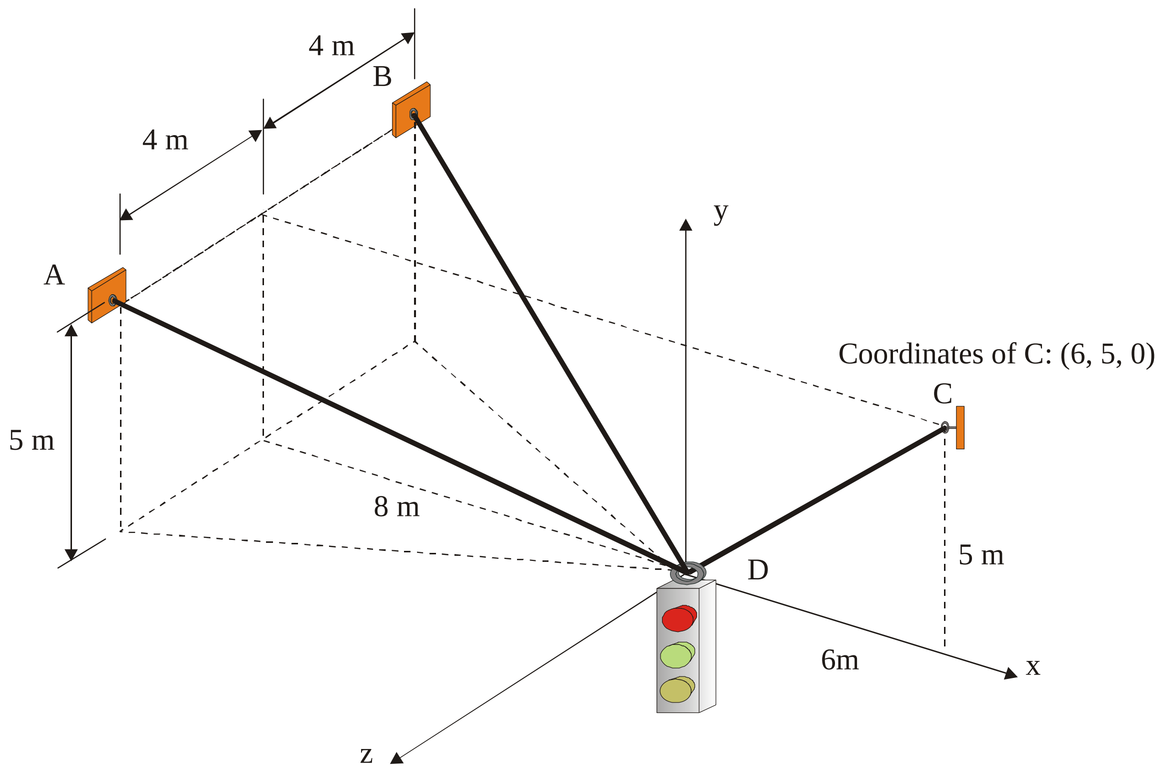
a) The external reactions at *A* and *F*, and
b) The forces acting on each member of the frames and on the pulleys at *C* and *E*.



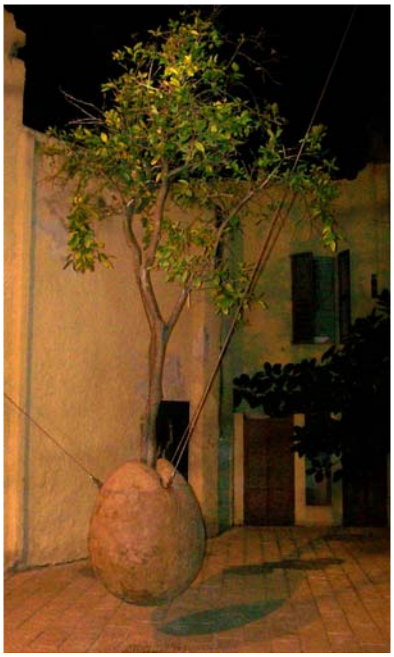
S2-501 Three cables that are in tension are attached at *O*. Determine the magnitude and direction of the resultant force at *O*.

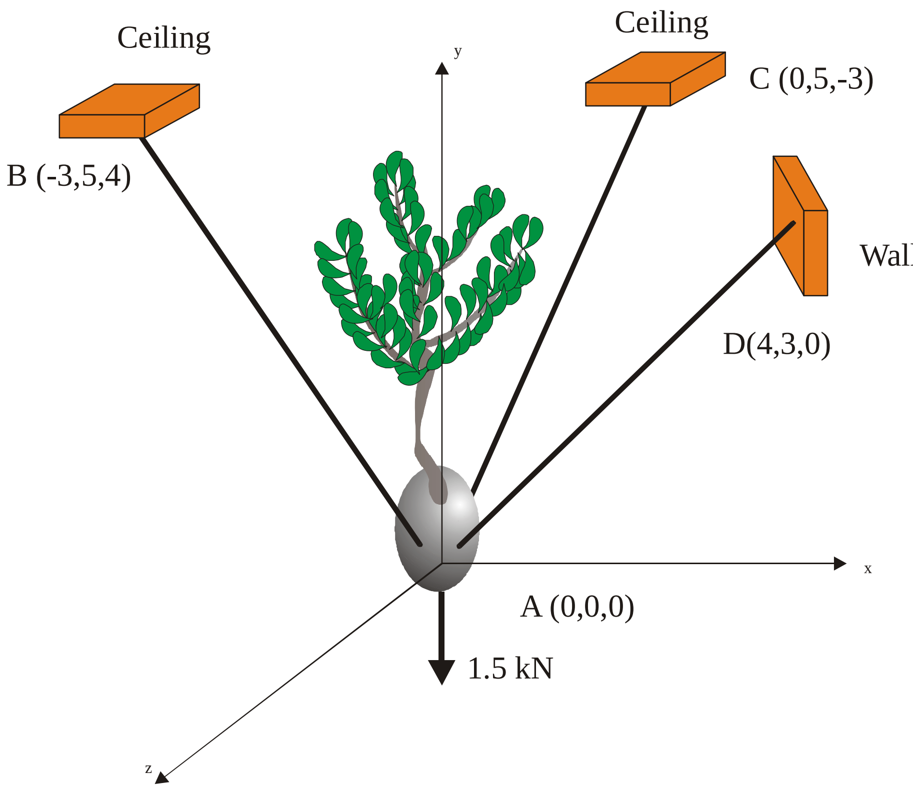


S2-502 A traffic light that weighs *800 N* is suspended by means of three *(3)* cables as shown in the figure below. Draw an appropriate FBD and determine the tension in cables *DA*, *DB* and *DC*.

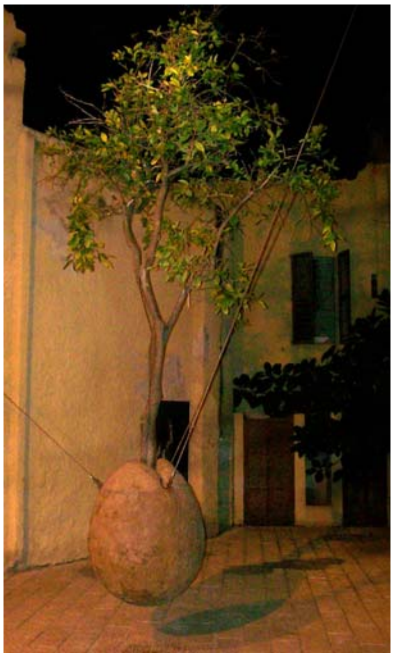


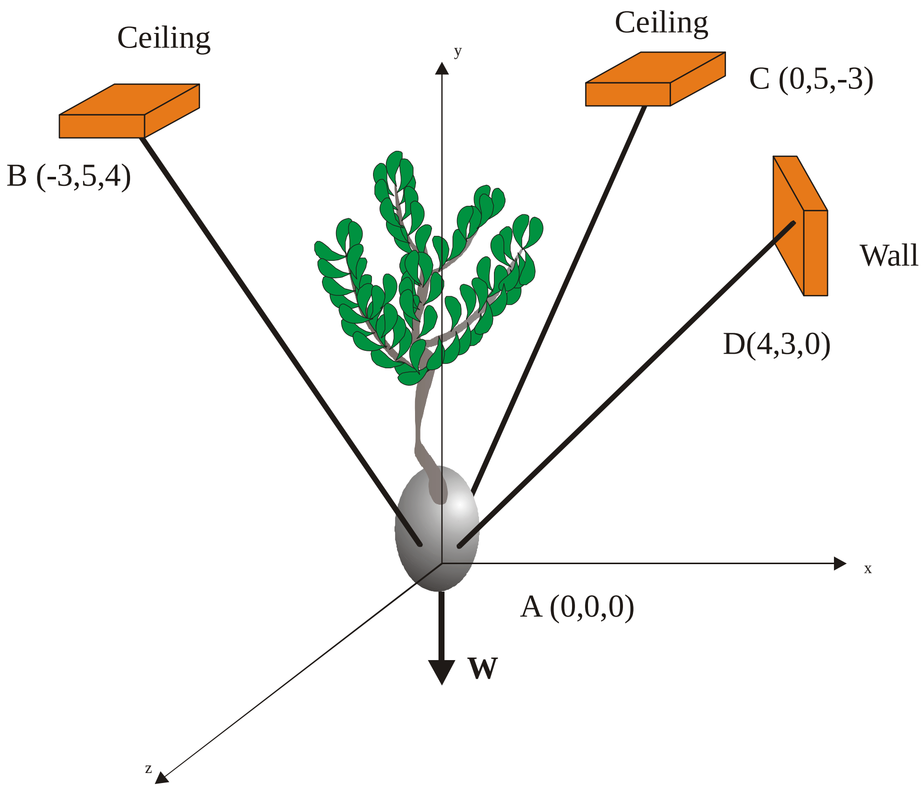
S2-503 A tree that weighs *1.5 kN* is suspended by two cables from the ceiling at *B* and *C* and by a third cable attached to the wall at *D*. Determine the tension in the three cables that support the tree. All dimensions are in metres.



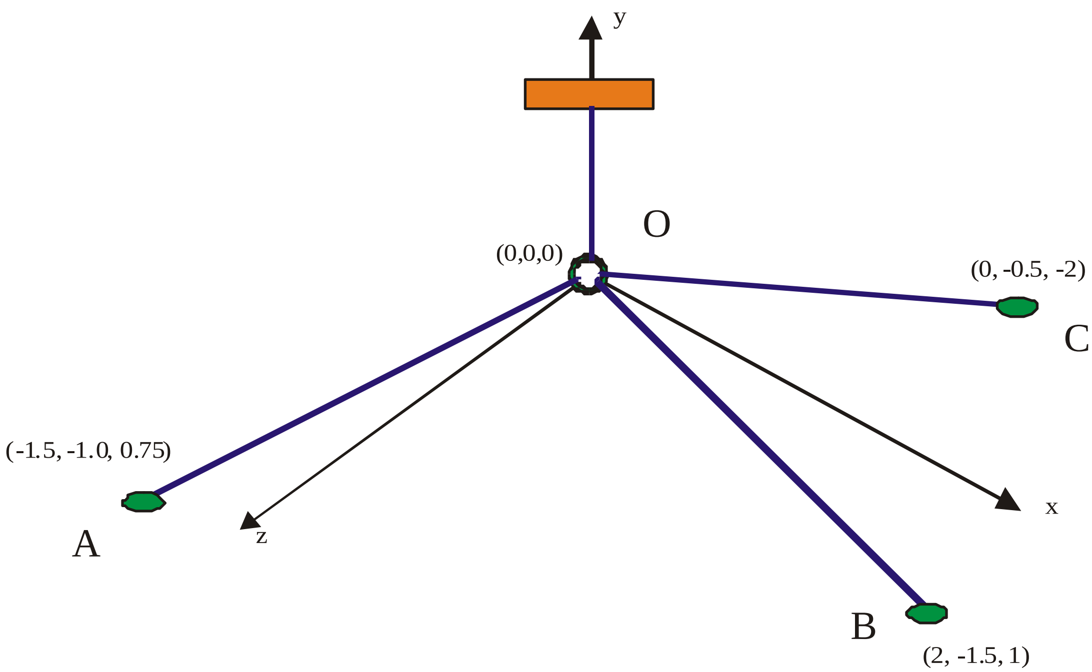


S2-504 A tree is suspended by two cables from the ceiling at *B* and *C* and by a third cable attached to the wall at *D*. If the maximum safe tension force in any one of the three cables is *1.2 kN*, Determine the maximum weight of the tree that can be supported.

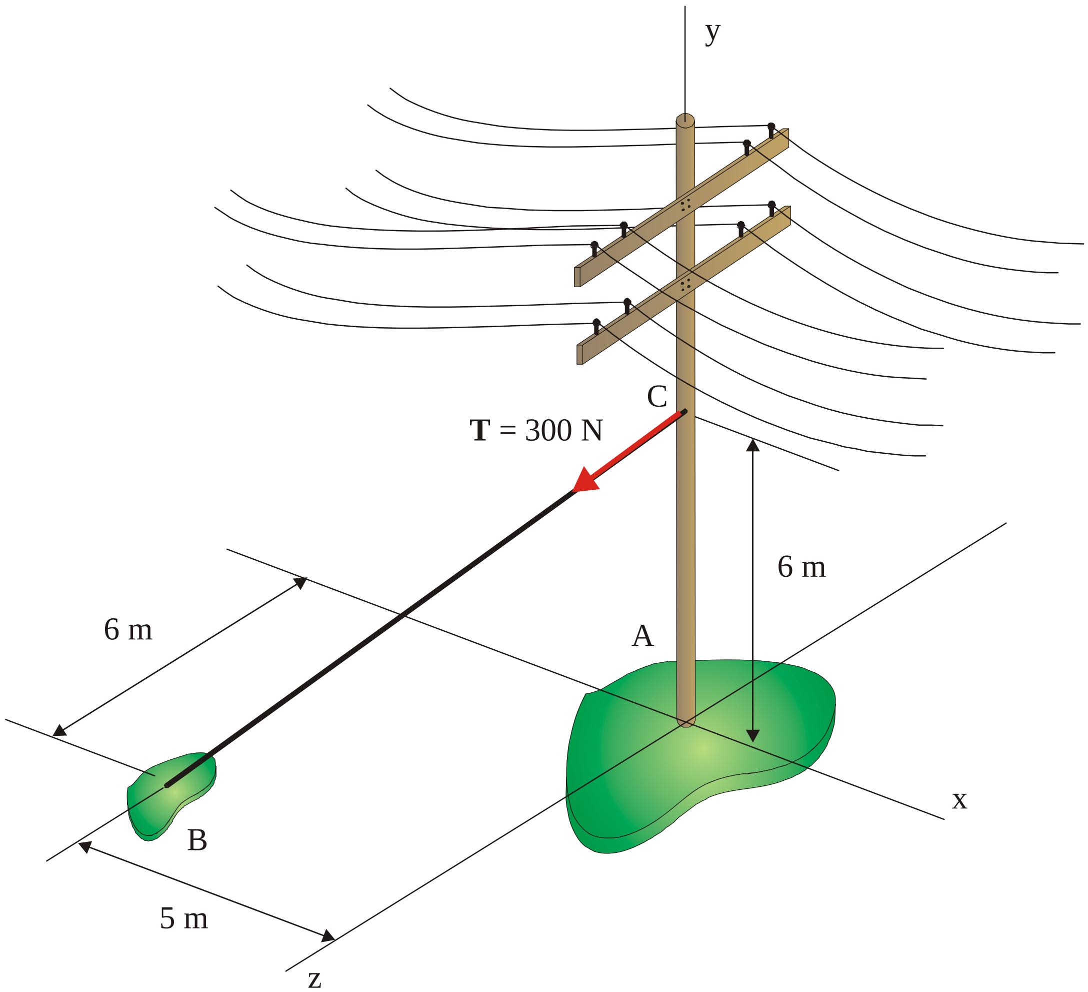




S2-505 An airplane that weighs 2.5 kN is suspended by three (3) cables attached to a ring. The coordinates of the cable attachment points to the airplane are provided in the figure. Draw a FBD and determine the tension in each cable.



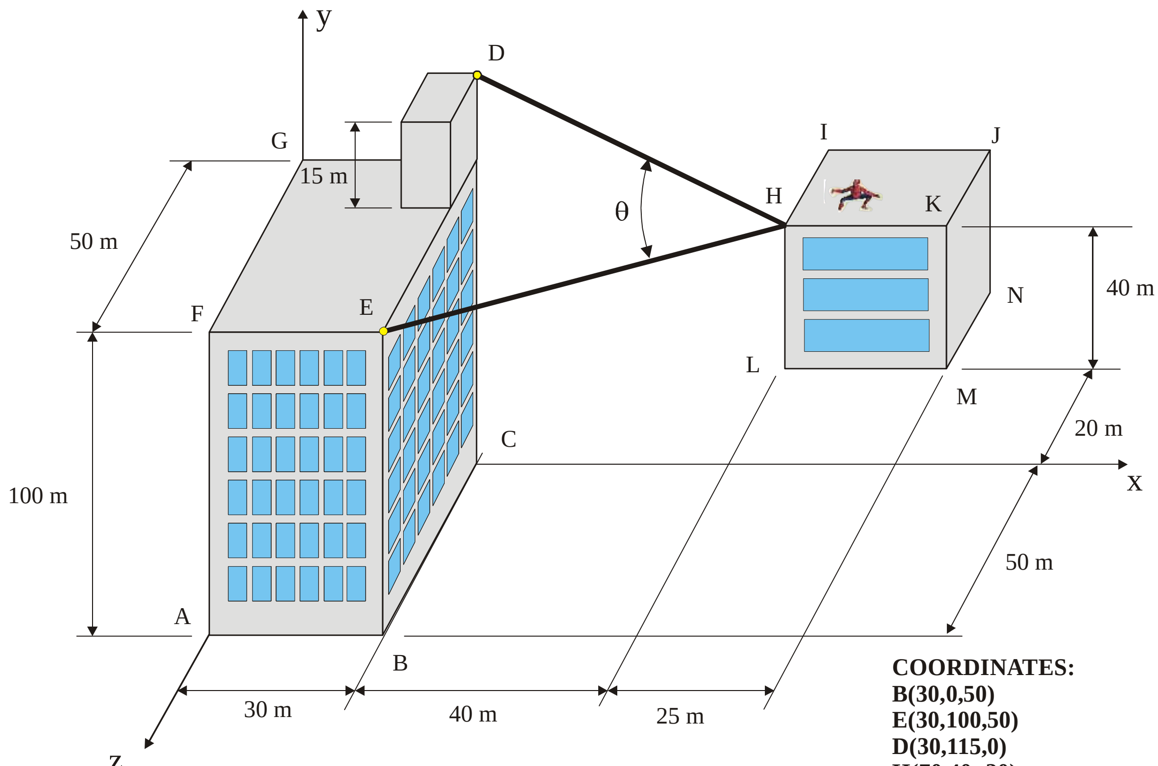
S2-601 A cable attached to the telephone pole exerts a *300 N* force on the pole. Determine the moment of this force about the point *A*.



S2-602 Spiderman casts two web lines *HE* and *HD* across two buildings as shown in the figure below. In doing so, he applied a force of *150 N* on line *HE* and *250 N* on line *HD* pulling from point *H*.

Determine:

a) The resultant, ***R***, of the two forces acting at the point *H*,
b) The angle, θ, between the two web lines at *H*,
c) The moment of the resultant, ***R***, about the point *B*, and
d) The moment of the resultant, ***R***, about the line *BM*.



COORDINATES:
B(30,0,50)
E(30,100,50)
D(30,115,0)
H(70,40,-20)
M(95,0,-20)

S2-603 A force ***P*** of magnitude *2600 N* acts on the frame shown at point *E*. Determine:

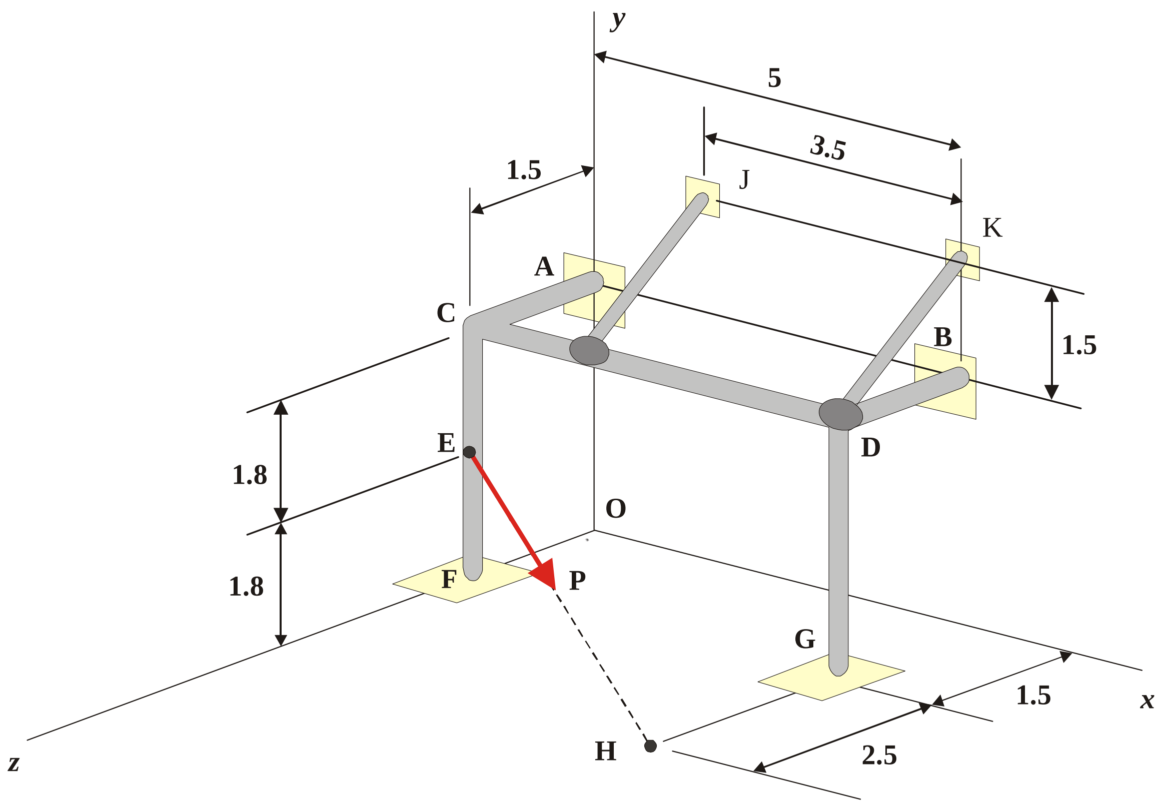
a) The moment of ***P*** about the point *D*.

b) The moment of ***P*** about the line joining points *O* and *D*.

c) The perpendicular distance from the line of action of ***P*** to the point *D*.

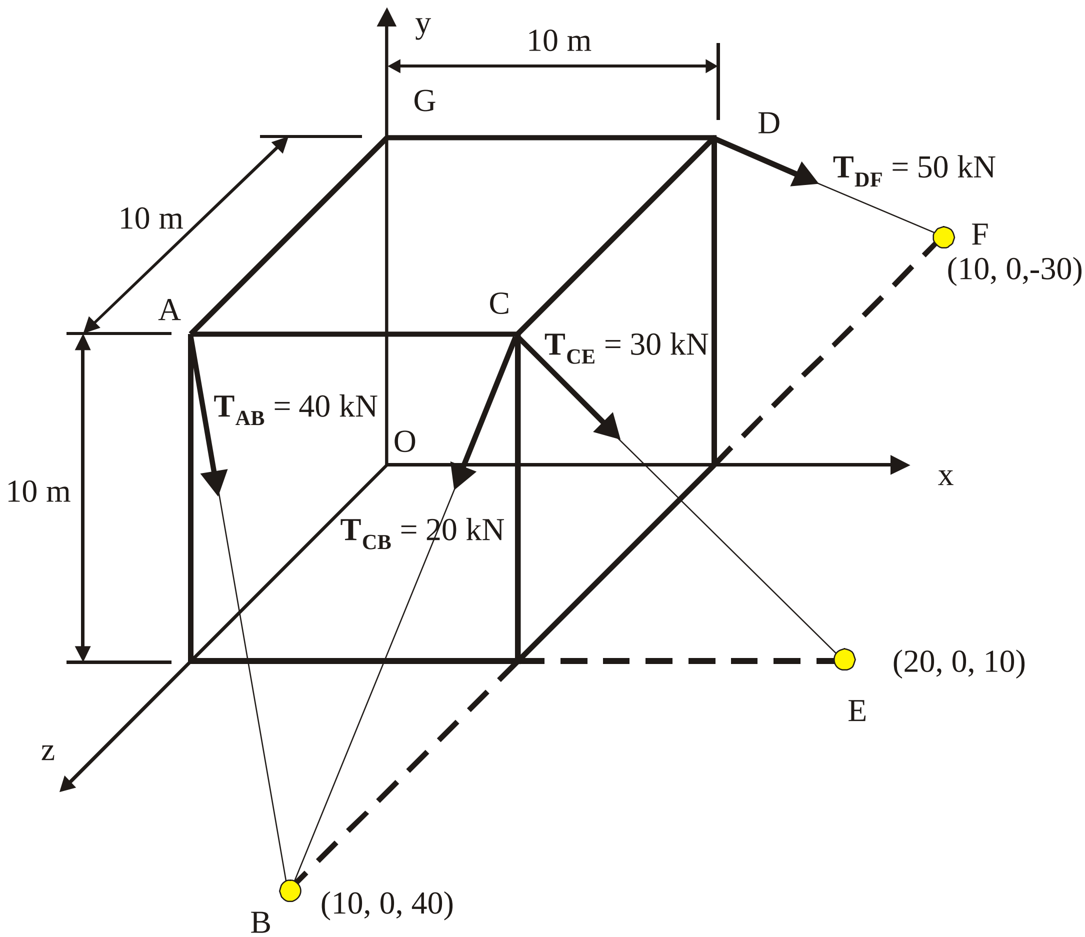
d) The moment of ***P*** about the line joining points *E* and *K*.

All dimensions are in metres



S2-604 Four forces (***T****AB*, ***T****CB*, ***T****CE*, and ***T****DF*) are shown acting at the corners of a box. Determine:

a) The total moment that the four forces have about the <u>Line *AB*</u>, and
b) The angle between the forces ***T****CB* and ***T****CE*.

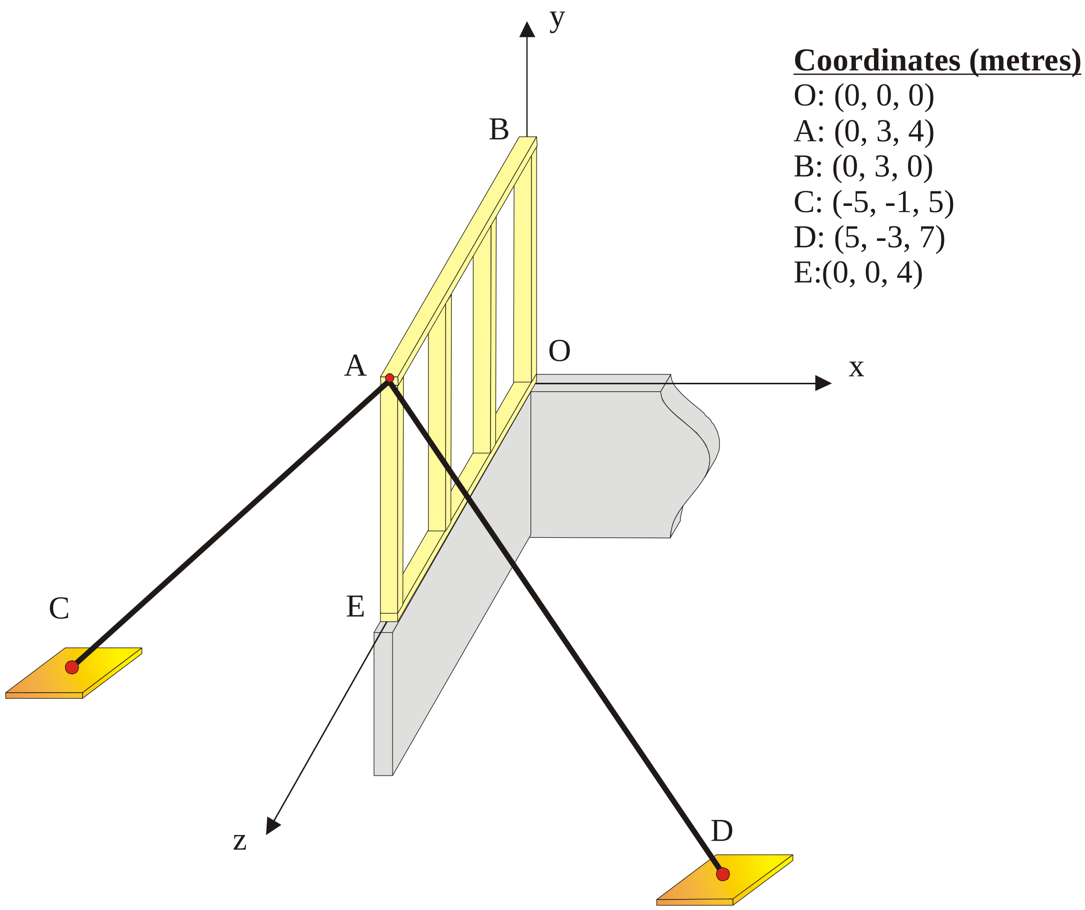


S2-605 A *3 m x 4 m* wood stud wall sits on top of a concrete foundation wall as shown in the figure. The stud wall is bolted to the foundation wall and is supported by two cables *AC* and *AD* attached to the wall at point *A*. The tension in cable *AC* is *1.2 kN*. Determine:

(a) The angle between cable *AC* and cable *AD*,

(b) The moment of the *1.2 kN* force applied at *A* by cable *AC* about the line *EO*,

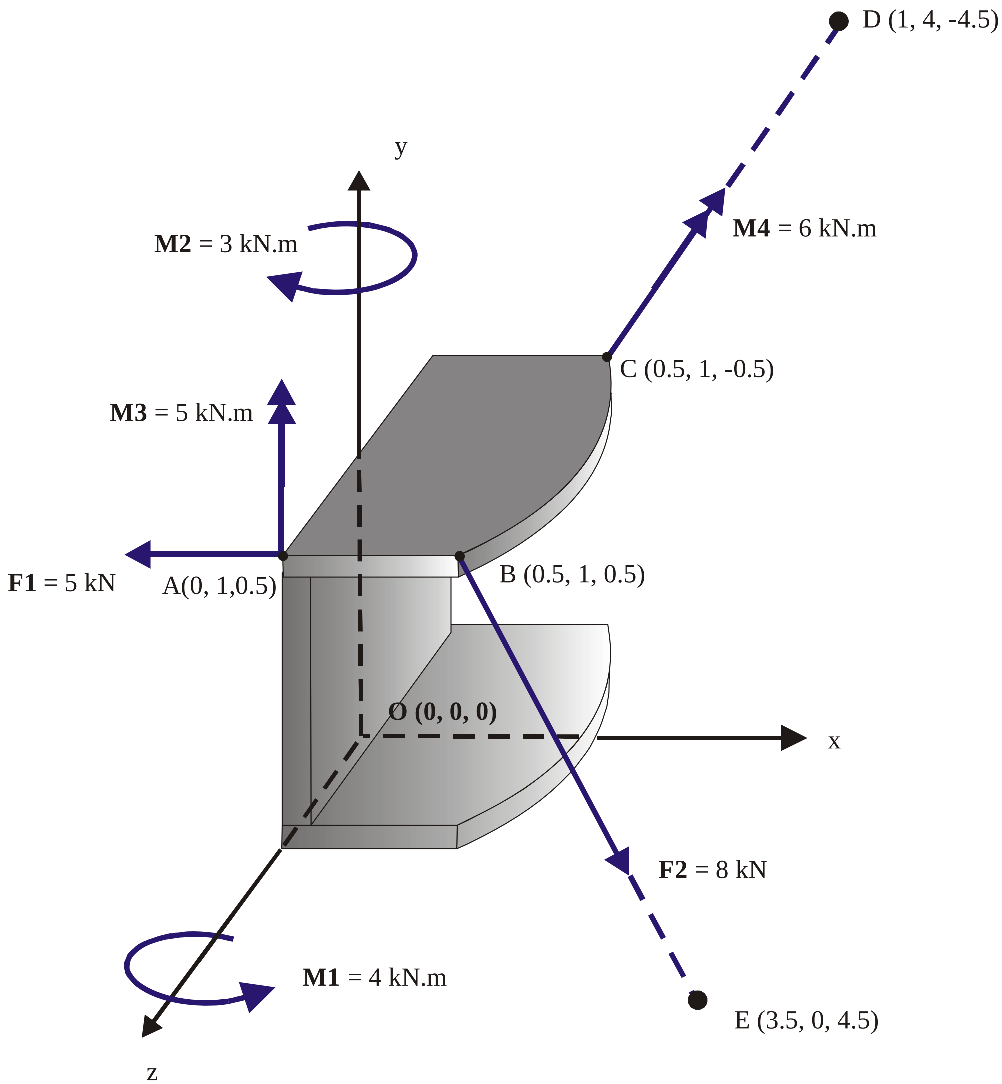
(c) The moment of the *1.2 kN* force applied at *A* about the line *CD* and



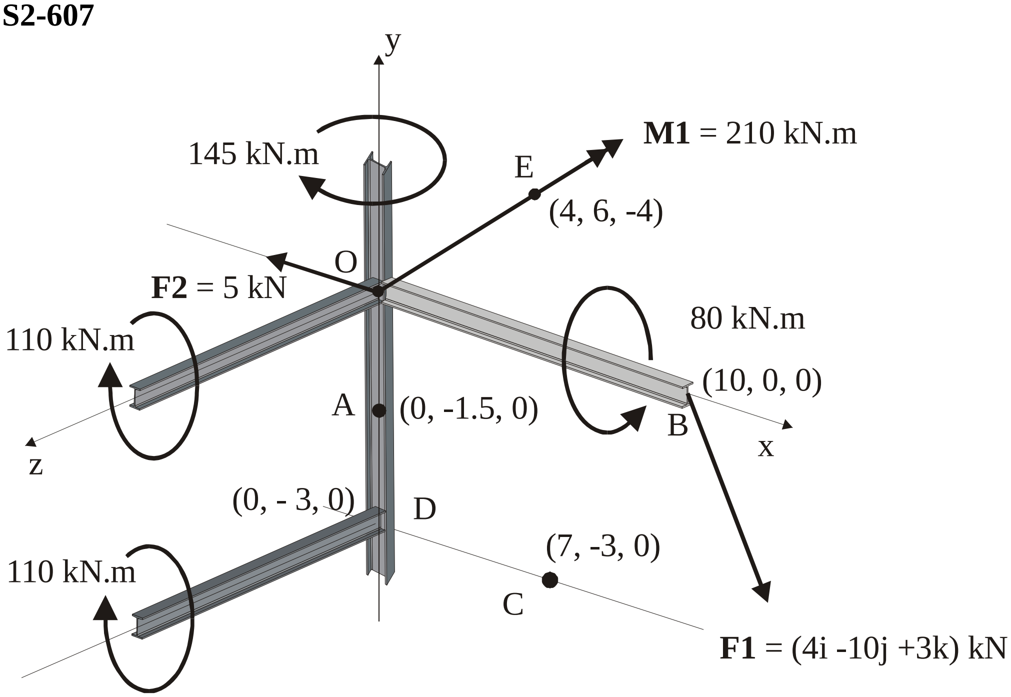
S2-606 Four couple moments and two forces act on a bracket as shown in the figure.

Determine:

a) The equivalent force-couple acting at the origin, *O*,
b) The direction of the resultant couple at *O*, and
c) The perpendicular distance from *O* to the line-of-action of ***F2***.



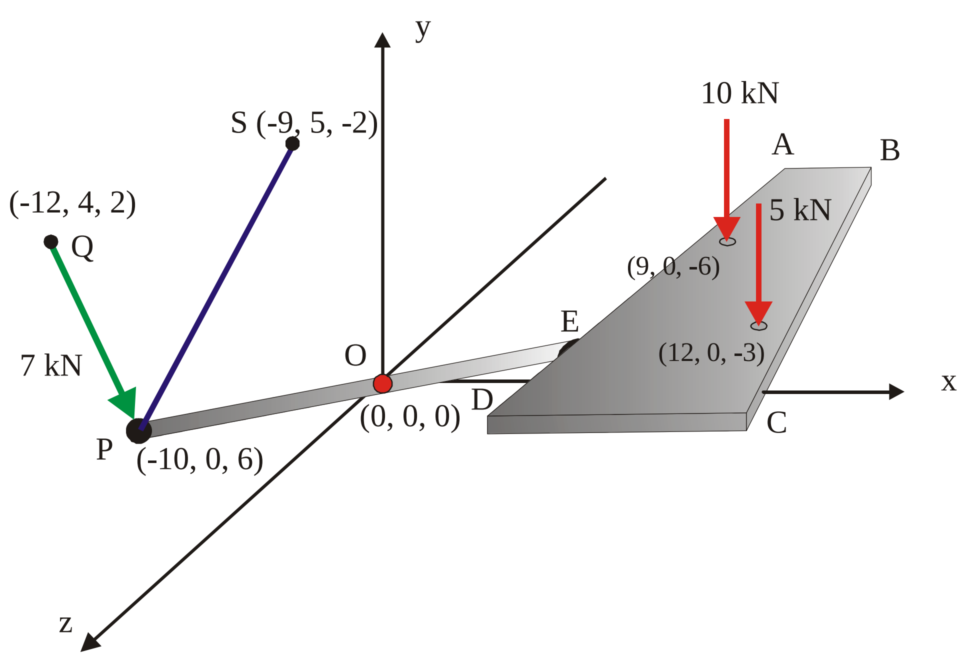
S2-607



a) Determine the equivalent-force couple acting at Point D.
b) What is the direction of the resultant moment vector at Point D?
c) What is the direction of the resultant force vector at Point D?
d) What is the perpendicular distance from Point D to the line-of-action of F1?
e) What is the moment of F1 about the Line AC?

S2-608 The trapezoidal plate, *ABCD*, lies in the *x-z* plane. Two vertical loads of *10 kN* and
5 kN are applied to the plate at the locations indicated in the figure. The pipe, *POE* also lies in the *x-z* plane and is attached to the plate at *E*. A 7 *kN* force is applied at end *P* of the pipe.

a) Replace the *10 kN* and *5 kN* force with a single force, ***R***, and determine its point of application on the plate.
b) Determine the equivalent force-couple acting at *O* and determine the direction of both the force and the couple acting at *O*.
c) Determine the projection of the *7 kN* force onto the line *PS*.



S2-609 A UFO (Unidentified Flying Object) landed in South Winnipeg (near the U of M campus) and was seen taking off carrying three (3) unidentified packages (rumor has it they were Engineering students). The masses of the students are $M_1 = 100\ kg$, $M_2 = 65\ kg$ and $M_3 = 140\ kg$. Their location in the $5\ m$ radius space craft is shown in Figure 1(b) below.

The message back from the space craft is that the students will be returned if you can replace these forces by a single force and correctly locate its point of application with respect to the origin, O in the figure. **(Use g = 9.8 m/sec^2**

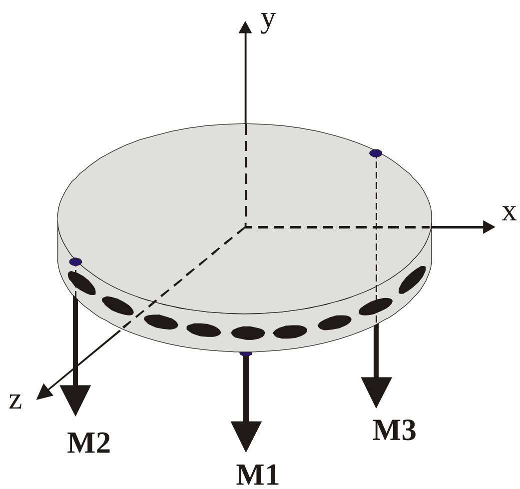


Figure 1(a)

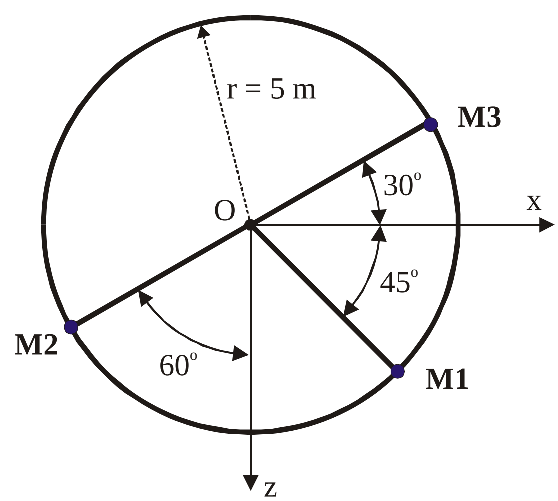


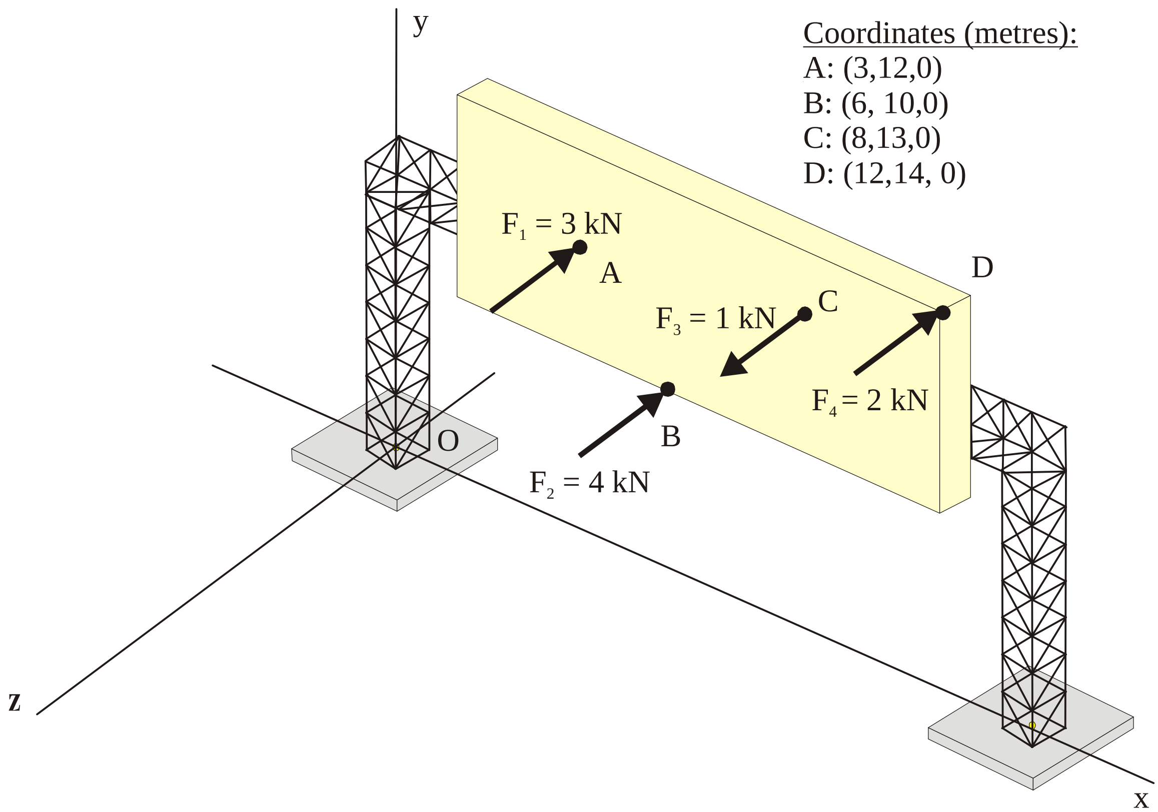
Figure 1(b) - Location of Masses

S2-610 Four forces are applied to the highway sign at points *A*, *B* , *C*, and *D* as shown. (All forces are parallel to the *z* – axis.) The coordinates of the points with respect to the origin *O* are also specified.

Determine:

(a) the magnitude and direction of the resultant of the resultant of the four forces, and

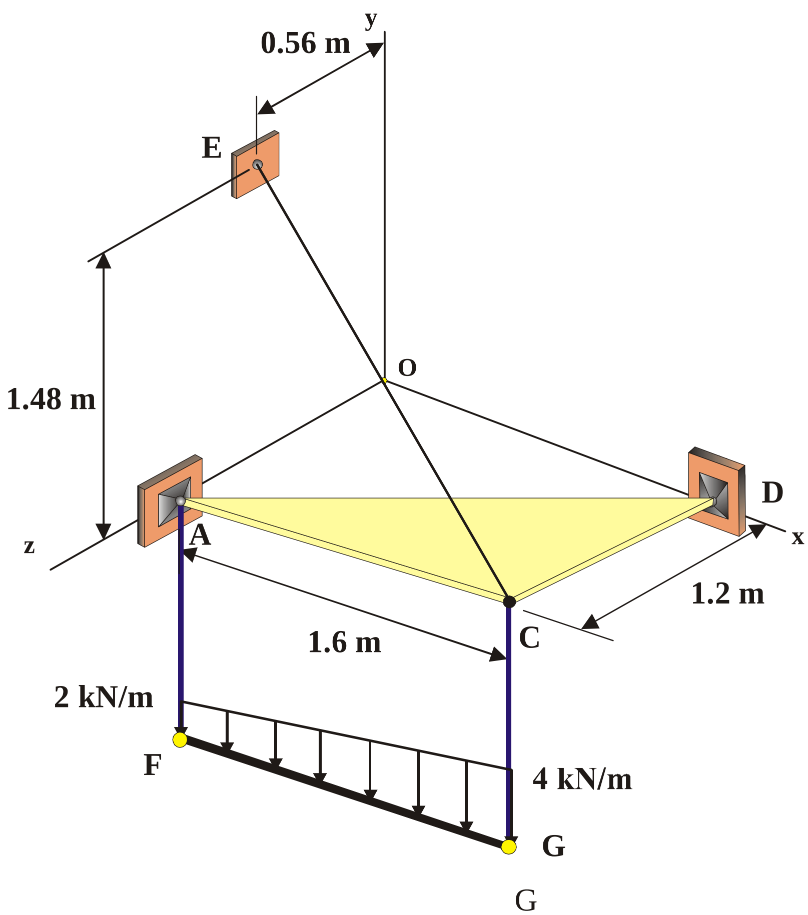
(b) the point of application of the resultant with respect to the origin *O*.



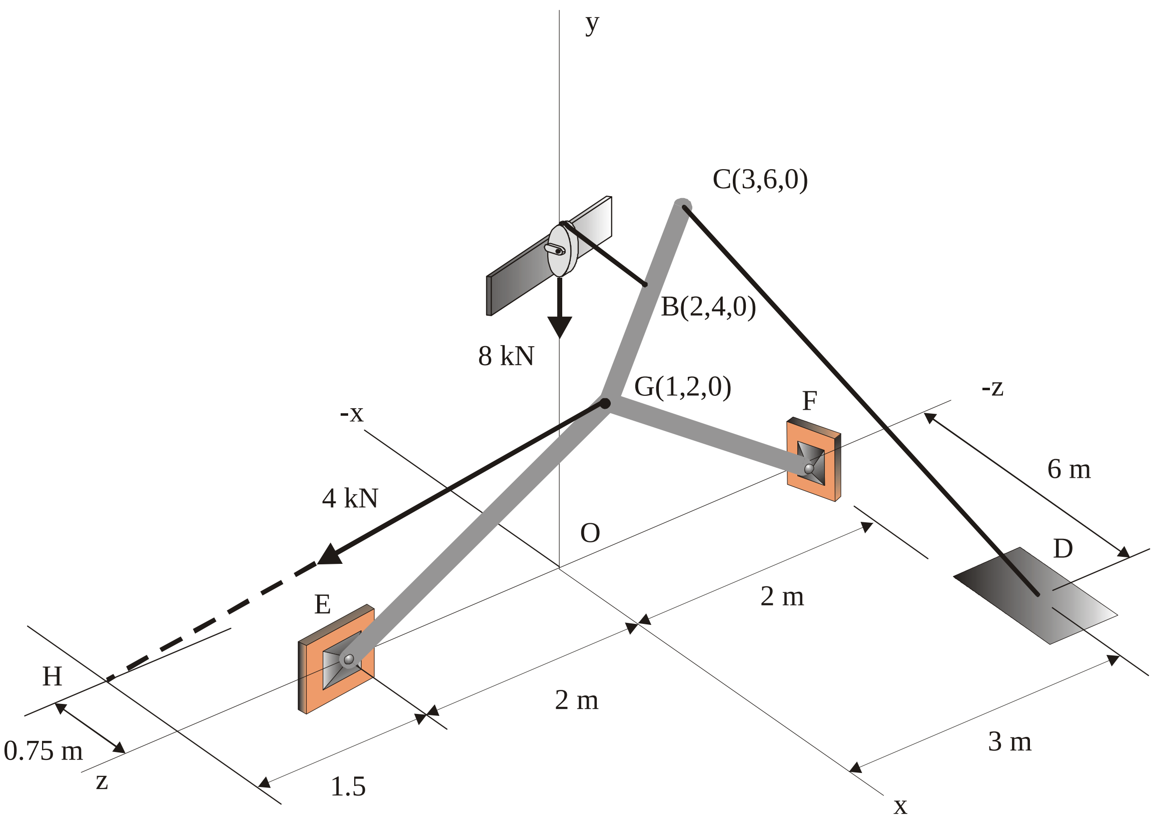
S2-611 A triangular plate is supported by ball-and-socket joints at *A* and *D* and by a cable attached to the plate at *C*. The beam, *FG*, is suspended from the plate by cables *AF* and *CG* attached to the plate at A and at C as shown. The beam supports a distributed load that varies from *2 kN/m* to *4 kN/m* as shown in the figure. You may neglect the weight of the beam. Determine:

a) the tension in the cables supporting the beam, and

b) the tension in the cable *CE*.

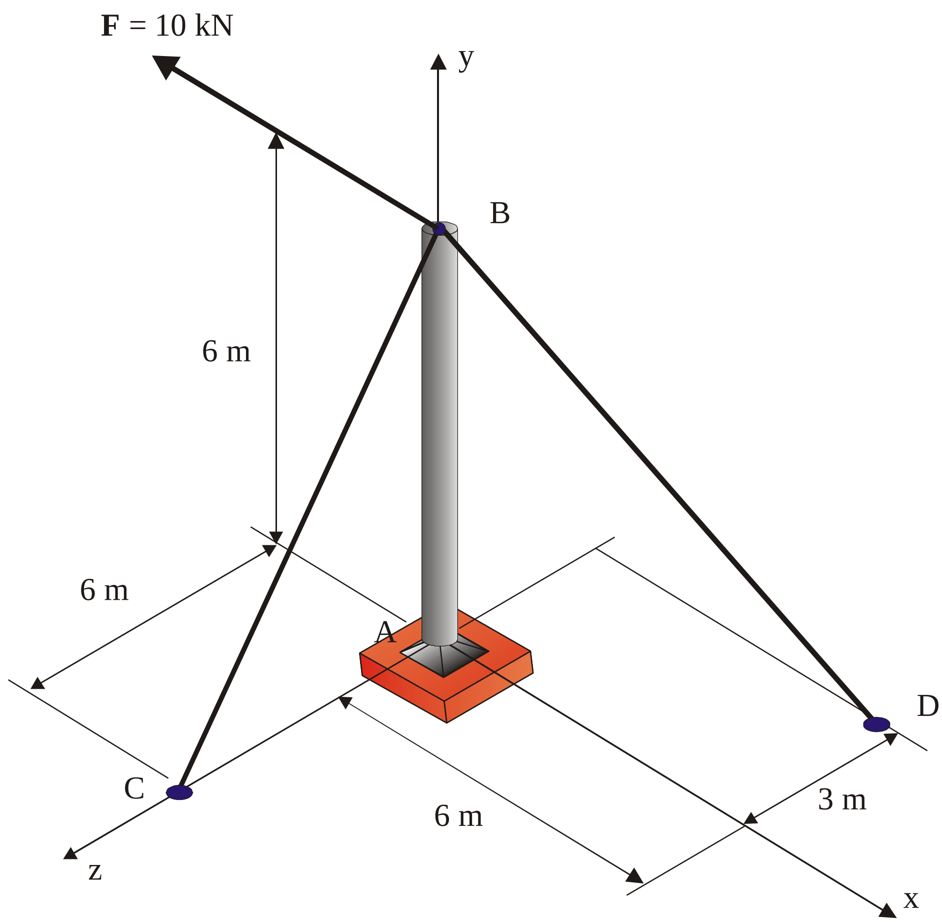


S2-612 A *8 kN* weight is suspended from a cable that passes over a smooth pulley at is attached to a frame at *B*. The upper part of the cable is horizontal and aligned with the x-axis. A cable, *CD*, connects the top of the frame, C, to the ground at *D*. A third cable is attached to the frame at *G* and applies a *4 kN* force with a line-of-action from *G* to *H*. The frame is supported by ball and socket joints at *E* and *F*. Determine the tension in cable *CD*. (Note that *E*, *F*, *G* and *H* all lie in the *x*-*z* plane.)



S2-613 A *6 m* long pole has a ball-and socket joint at *A* and is supported by two *(2)* cables, *BD* and *BC* as shown in the figure below. A *10 kN* force acting in the *x-y* plane and parallel to the *x* axis is applied to the pole at *B*. Determine:

a) The tensions in the two cables,
b) The reactions at the ball-and-socket joint at *A*,
c) The angle between cables *BC* and *BD* and
d) The moment of the *10 kN* force about the line *CD*.



ANSWERS TO SERIES II PROBLEM SET

CHAPTER 2

S2-201 $F_b = 60.128$ N, $\alpha = 56.26^o$

S2-202 R = 250 kN, $T_{BC} = 321.4$ kN

S2-203 $T_{AC} = 95.08$ N, R = 94.97 N

S2-204 $F_A = 519.62$ N, $F_B = 300$ N

S2-205 $\mathbf{T_{BC}} = 2.598$ kN $\rightarrow$, **R** = 1.5 kN $\uparrow$

S2-206 $67.11^o <= \alpha <= 90^o$

S2-207 (b) R = 724.6 N, $\theta = 26.1^o$ (c) $\alpha = -65.55^o$

S2-208 (a) **R** = 872.19^o 7.4^o , $\alpha = 6.3215^o$

S2-209 $\beta = 45.615^o$

S2-210 $T_{AD} = 19600$ N, $T_{CF} = 12602.8$ N, $T_{BE} = 15020.03$ N

S2-211 $\alpha = 26.38^o$, $\beta = 36.34^o$

S2-212 W = 6020.3 N, TBA = 4391.9 N, TBC = 3106 N, TDC = 3106 N, TDE = 3674.71 N

S2-213 11.38 kg

S2-214 $\mathbf{F_{BD}} = 11.55$ kN 1 2 , $\mathbf{F_{BC}} = 3.78$ kN 1 1

S2-215 T = 2500 N

S2-216 $T_1 = 490$ N, T_2 245 N

S2-217 $T_1 = 45$ kN, $T_2 = 90$ kN, $T_3 = 22.5$ kN, $T_4 = 22.5$ kN, $T_5 = 22.5$ kN

S2-218 $T_{AB} = 12.73$ kN, $T_{AC} = 37.11$ kN

CHAPTER 3

S2-301 $\alpha = 38.76^o$

S2-302 d = 1.639 m, P = 1049.61 N, $T_{EA} = 600$ N, $T_{EC} = 0$

S2-303 (a) $\mathbf{R_x} = 23.5$ N $\leftarrow$, $\mathbf{R_y} = 315$ N $\downarrow$, $\mathbf{M_{RA}} = 269.75$ kN.m

(b) F = 50.47 N 79.22^o

S2-304 (a) $\mathbf{R_x} = 200$ N $\rightarrow$, $\mathbf{R_y} = 1000$ N $\downarrow$, $\mathbf{M_{RO}} = 7333.33$ N.m

(b) x = 7.33 m, y = 36.67 m

S2-305 (a) $\mathbf{R_x} = 25$ N $\leftarrow$, $\mathbf{R_y} = 216.51$ N $\uparrow$, $\mathbf{M_{RO}} = 92.15$ N.m

(b) x = 0.426 m, y = 3.686 m

S2-306 (a) $\mathbf{R_x} = 40$ N $\rightarrow$, $\mathbf{R_y} = 30$ N $\downarrow$, $\mathbf{M_{RA}} = 1460$ N.m

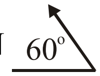
(b) x = 48.66 m, y = 36.5 m

S2-307 $\mathbf{A_y} = 15.1$ kN $\uparrow$, $\mathbf{B_x} = 0$, $\mathbf{B_y} = 3.4$ kN $\uparrow$

S2-308 $\mathbf{A_y} = 16.975$ kN $\uparrow$, $\mathbf{B_x} = 0$, $\mathbf{B_y} = 30.525$ kN $\uparrow$

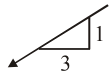
S2-309 $\mathbf{A_x} = 0$, $\mathbf{A_y} = 39$ kN $\uparrow$, $\mathbf{M_A} = 384$ kN.M

S2-310 $\mathbf{F_B} = 34 .86$ N 60^o , $\mathbf{C_x} = 22.57$ N $\leftarrow$, **Cy** = 19.81 N $\uparrow$

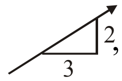
S2-311 $\mathbf{F_B}$ = 38.374 N 

, $\mathbf{F_E}$ = 20.813 kN $\leftarrow$, **Cy** = 16.768 kN $\uparrow$

S2-312 w = 2.47 kN/m
S2-313 (See Text/Notes)

S2-314 $\mathbf{F_C}$ = 15.811 

kN , $\mathbf{A_x}$ = 15 kN $\rightarrow$, $\mathbf{A_y}$ = 15 kN $\uparrow$

S2-315 $\mathbf{F_{BC}}$ = 622.27 N 

, $\mathbf{A_x}$ = 467.76 N $\leftarrow$, $\mathbf{A_y}$ = 258.57 N $\downarrow$

CHAPTER 4

S2-401 Simple truss – last joint checked must be in equilibrium.
S2-402 Simple truss – last joint checked must be in equilibrium.
S2-403 T_{AB} = 36 kN, Simple truss – last joint checked must be in equilibrium.
S2-404 Simple truss – last joint checked must be in equilibrium.

S2-405 $\mathbf{A_x}$ = 251.23 kN $\leftarrow$, $\mathbf{A_y}$ = 100 kN $\downarrow$, $\mathbf{D_x}$ = 251.24 kN $\leftarrow$,
$\mathbf{I_x}$ = 258.56 kN $\rightarrow$, $\mathbf{I_y}$ = 29.3 kN $\downarrow$
Simple truss – last joint checked must be in equilibrium.
S2-406 Simple truss – last joint checked must be in equilibrium.
S2-407 **T** at Joint F = 8 kN $\downarrow$ on the truss, **T** at Joint E = 6 kN $\downarrow$ on the truss,
Simple truss – last joint checked must be in equilibrium.
S2-408 Simple truss – last joint checked must be in equilibrium.
S2-409 Simple truss – last joint checked must be in equilibrium.
S2-410 Simple truss – last joint checked must be in equilibrium.

S2-411 (b) $\mathbf{A_x}$ = 3.96 kN $\leftarrow$, $\mathbf{A_y}$ = 8.364 kN $\uparrow$, $\mathbf{M_A}$ = 131.36 kN.m $\circlearrowleft$
(c) Simple truss – last joint checked must be in equilibrium.
S2-412 Simple truss – last joint checked must be in equilibrium.
S2-413 48.61 kN Tension < 75 kN and 122.98 kN compression < 150 kN, Lift OK
S2-414 Simple truss – last joint checked must be in equilibrium

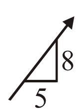
S2-415 $\mathbf{A_x}$ = 0, $\mathbf{A_y}$ = 7.07 kN $\downarrow$, $\mathbf{B_y}$ = 67.47 kN $\uparrow$, $\mathbf{E_y}$ =0.4 kN $\downarrow$

S2-416 $\mathbf{A_x}$ = 0, $\mathbf{A_y}$ = 42.5 kN $\uparrow$,$\mathbf{M_A}$ = 316.8 kN.m $\circlearrowleft$, $\mathbf{D_y}$ = 2.66 kN $\uparrow$, $\mathbf{E_y}$ =0.167 kN $\downarrow$

S2-417 $\mathbf{A_x}$ = 0, $\mathbf{A_y}$ = 10.167 kN $\downarrow$, $\mathbf{B_y}$ = 20.5 kN $\uparrow$, $\mathbf{C_y}$ = 0.333 kN $\downarrow$

S2-418 $\mathbf{A_x}$ = 0, $\mathbf{A_y}$ = 10.5 kN $\downarrow$, $\mathbf{B_y}$ = 20.5 kN $\uparrow$, $\mathbf{C_y}$ = 41 kN $\uparrow$, $\mathbf{D_y}$ = 20.5 kN $\downarrow$ $\downarrow$

S2-419 F_{BD} = 821.49 N Tension, F_{AD} = 1901.44 N Compression

S2-420 (a) $\mathbf{F_C}$ = 21.62 kN 

, $\mathbf{E_x}$ = 16.46 kN $\leftarrow$, $\mathbf{E_y}$ = 6.33 kN $\uparrow$

(b) Check your answer(s) by taking moments about a different point.

S2-421 $\mathbf{C_x} = 1920\text{ N} \rightarrow$, $\mathbf{F_B} = 2000\text{ N}$ 3 4 on CBD, $\mathbf{D_x} = 320\text{ N} \leftarrow$

For Problems S2-422 to S2-436 inclusive, <u>only partial answers</u> (external reactions) are provided. Students can check internal forces by drawing Free Body Diagrams of individual members and in some cases the pins connecting members or pins connecting members to an external support and applying the equilibrium equations. The moment equilibrium equation should be applied about a point other than the point used in the initial analysis.

S2-422 (a) $\mathbf{A_x} = 20\text{ kN} \leftarrow$, $\mathbf{A_y} = 15\text{ kN} \uparrow$, $\mathbf{E_x} = 20\text{ kN} \rightarrow$

S2-423 (a) $\mathbf{A_x} = 2.8\text{ kN} \leftarrow$, $\mathbf{A_y} = 4\text{ kN} \downarrow$, $\mathbf{D_x} = 2.8\text{ kN} \rightarrow$, $\mathbf{D_y} = 6\text{ kN} \uparrow$

S2-424 (a) $\mathbf{A_x} = 3\text{ kN} \rightarrow$, $\mathbf{A_y} = 0.3\text{ kN} \uparrow$, $\mathbf{B_y} = 5.7\text{ kN} \uparrow$

S2-425 (a) $\mathbf{A_x} = 66.25\text{ kN} \leftarrow$, $\mathbf{A_y} = 31.67\text{ kN} \downarrow$, $\mathbf{E_x} = 66.25\text{ kN} \rightarrow$, $\mathbf{E_y} = 111.67\text{ kN} \uparrow$

S2-426 (a) $\mathbf{A_x} = 1292.02\text{ kN} \leftarrow$, $\mathbf{A_y} = 674.75\text{ kN} \downarrow$

$\mathbf{D_x} = 1292.02\text{ kN} \rightarrow$, $\mathbf{D_y} = 1174.75\text{ kN} \uparrow$

S2-427 (a) $\mathbf{A_x} = 4.55\text{ kN} \leftarrow$, $\mathbf{A_y} = 2.23\text{ kN} \downarrow$, $\mathbf{C_x} = 4.56\text{ kN} \rightarrow$, $\mathbf{C_y} = 1.47\text{ kN} \uparrow$

$\mathbf{E_y} = 4.76\text{ kN} \uparrow$

S2-428 $\mathbf{F_A} = 5.08\text{ kN}$ 4 3 , $\mathbf{F_C} = 6.82\text{ kN}$ 2 1

S2-429 (a) $\mathbf{A_x} = 1.625\text{ kN} \rightarrow$, $\mathbf{A_y} = 3\text{ kN} \uparrow$, $\mathbf{C_x} = 1.625\text{ kN} \leftarrow$, $\mathbf{C_y} = 7\text{ kN} \uparrow$

S2-430 (a) $\mathbf{A_x} = 3.5\text{ kN} \rightarrow$, $\mathbf{A_y} = 3\text{ kN} \uparrow$, $\mathbf{F_C} = 7.83\text{ kN}$ 2 1

S2-431 (a) $\mathbf{A_x} = 5.62\text{ kN} \leftarrow$, $\mathbf{A_y} = 32.49\text{ kN} \uparrow$, $\mathbf{M_A} = 15\text{ kN.m} \circlearrowleft$
$\mathbf{F_C} = 34.25$ kN (member DC in compression), $\mathbf{B_X} = 6.875\text{ kN} \rightarrow$ on BDE
BY = 23.32 kN $\uparrow$ on BDE

S2-432 (a) $\mathbf{A_x} = 67.19\text{ kN} \rightarrow$, $\mathbf{A_y} = 25\text{ kN} \uparrow$, $\mathbf{B_x} = 23.89\text{ kN} \leftarrow$

S2-433 (a) $\mathbf{A_x} = 0$, $\mathbf{A_y} = 276.92\text{ kN} \uparrow$, $\mathbf{D_y} = 623.08\text{ kN} \uparrow$

S2-434 a) $\mathbf{A_x} = 1062.5\text{ kN} \leftarrow$, $\mathbf{A_y} = 750\text{ kN} \uparrow$, $\mathbf{B_x} = 1062.5\text{ kN} \rightarrow$, $\mathbf{B_y} = 1750\text{ kN} \uparrow$

S2-435 (a) AB and BC are 2-force members (b) T = 1836.1 N

	(c) $\mathbf{A_x}$ = 427.81 N $\longrightarrow$, $\mathbf{A_y}$ = 926.1 N $\downarrow$
S2-436	(a) $\mathbf{A_x}$ = 50 kN $\longleftarrow$, $\mathbf{A_y}$ = 20 kN $\downarrow$, $\mathbf{F_y}$ = 70 kN $\uparrow$

CHAPTER 5

S2-501	$\mathbf{R} = 841.08\mathbf{i} + 557.5\mathbf{j} + 193.88\mathbf{k}$, $\theta_x = 35.13^o$, $\theta_y = 57.17^o$, $\theta_z = 78.86^o$
S2-502	T_{AD} = 351.32 N, T_{DB} = 351.32 N, T_{DC} = 714.08 N
S2-503	T_{AB} = 0.762 kN, T_{AD} = 0.404 kN, T_{AC} = 0.839 kN
S2-504	W = 2.15 kN
S2-505	T_{OA} = 1.954 kN, T_{OB} = 2.021 kN, T_{OC} = 1.547 kN

CHAPTER 6

S2-601	$\mathbf{M_A} = (1096.56\mathbf{i} + 913.8\mathbf{k})$ N.m
S2-602	(a) $\mathbf{R} = (-174.22\mathbf{i} + 304.28\mathbf{j} + 161.74\mathbf{k})$ N.m (b) $\theta = 31.28^o$
	(c) $\mathbf{M_B} = (27769.2\mathbf{i} + 5701.6\mathbf{j} + 19140\mathbf{k})$ N.m (c) M_{BM} = 4869.9 N.m
S2-603	(a) $\mathbf{M_D} = (-1992.22\mathbf{i} + 5533.95\mathbf{j} + 22135.88\mathbf{k})$ N.m (b) M_{OD} = 6807.13 N.m
	(c) d = 8.81 m, (d) $\mathbf{M_{EK}}$ = 0 (line-of-action of **P** passes through line EK)
S2-604	(a) M_{AB} = 523.53 kN.m counter-clockwise looking A to B (b) $\theta = 77.08^o$
S2-605	(a) $\theta = 75.1^o$ (b) M_{OD} = 5.32 kN.m (c) M_{CD} = 0
S2-606	(a) $\mathbf{R_O} = (-0.29\mathbf{i} + 3.58\mathbf{j} - 4.78\mathbf{k})$ kN, $\mathbf{M_{RO}} = (7.67\mathbf{i} + 2.32\mathbf{j} - 1.28\mathbf{k})$ kN.m
	(b) $\theta_x = 19.06^o$, $\theta_y = 73.39^o$, $\theta_z = 99.08^o$ c) d =1.12 m
S2-607	(a) $\mathbf{R_D} = (-\mathbf{i} - 10\mathbf{j} + 3\mathbf{k})$ N.m, $\mathbf{M_D} = (190.86\mathbf{i} - 22.2\mathbf{j} - 215.14\mathbf{k})$ kN.m
	(b) $\theta_x = 48.57^o$, $\theta_y = 94.41^o$, $\theta_z = 138.23^o$ (c) $\theta_x = 95.47^o$, $\theta_y = 162.45^o$, $\theta_z = 73.38^o$
	(d) d = 10.4 m (e) M_{AC} = 10.701 kN.m
S2-608	(a) x = 10 m, z = -5 m (b) $\mathbf{R_O} = -15\,\mathbf{j}$, $\mathbf{M_{RO}} = (-47\mathbf{i} = 60.7\mathbf{j} + 46.7\mathbf{k})$ kN.m
	(c) 6.149 kN
S2-609	x = 2.62 m, z = 0.934 m
S2-610	x = 6.125 m, y = 11.375 m
S2-611	(a) T_{AF} = 2.13 kN, T_{CG} = 2.67 kN (b) T_{CE} = 4.09 kN
S2-612	T_{CD} = 6.815 kN
S2-613	(a) T_{BC} = 6.97 kN, T_{BD} = 14.93 kN (b) $\mathbf{F_{Ay}} = 14.93\mathbf{j}$, $\mathbf{F_{Ax}} = \mathbf{F_{Az}} = 0$
	(c) $\theta = 76.37^o$ (d) M_{CD} = 47.92 kN.m