2.0 Practice Problem Solutions

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3.1 You have to analyze a structure supporting two traffic lights and a traffic sign. Draw a physical model and FBD of the structural system shown in Fig. P3.1. Assume that the weights of the supporting structure, of the traffic lights, and of the sign are known. Further assume that the size of the traffic light is small enough that the wind has a negligible effect.

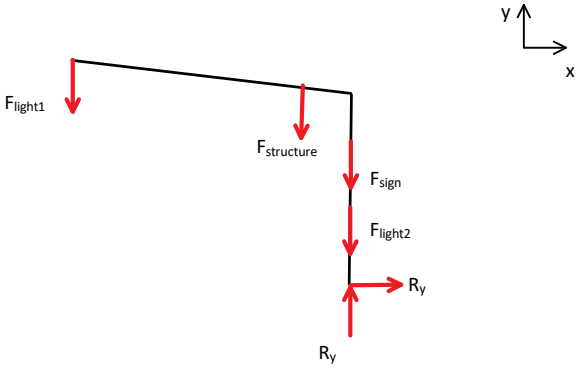


Fig. P3.1 Traffic light

3.4 A cloth rack in a dormitory is loaded by a number of cloth items as seen in Fig. P3.4. Draw the physical model and FBD of the rack.

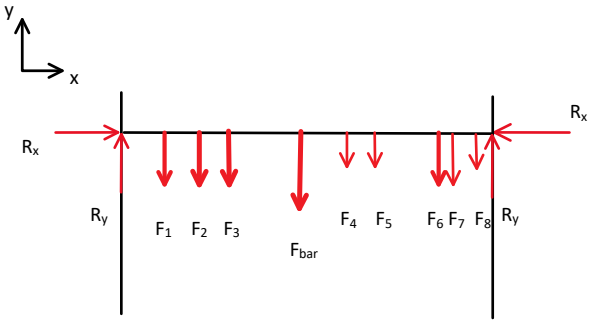


Fig. P3.4 Closet

3.8 Draw a physical model and FBD required for the analysis of the lamp pole shown in Fig. P3.7.

Include a side force due to wind

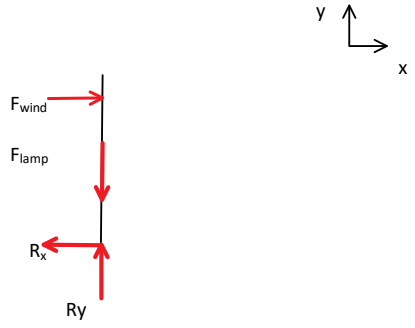


Fig. P3.7 Lamp pole

3.10 Draw a physical model and FBD of a C clamp (Fig. P3.9).

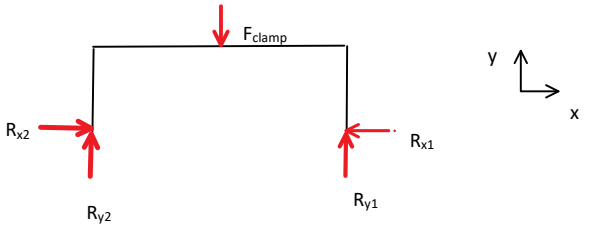


Fig. P3.9 C clamp

3.18 A person is pulling a rope attached to the middle of a bar fixed between two pillars (Fig. P3.15). Draw a physical model and FBD of the bar. Neglect the weight of the bar.

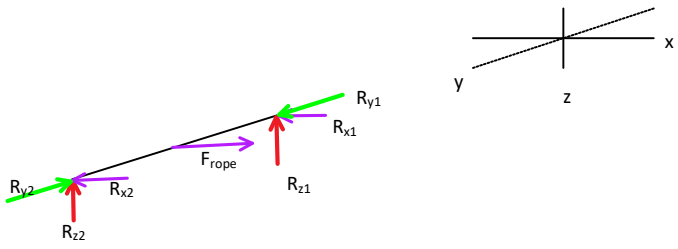
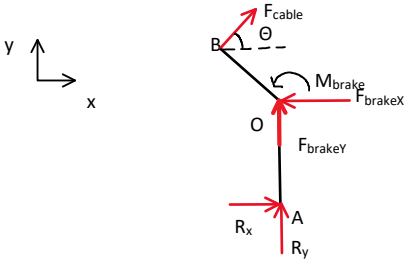


Fig. P3.15 Fixed bar

3.21 A bike brake consists of two pieces AOB and COD (Fig. P3.17). Draw a physical model and associated FBD for structural element AOB.

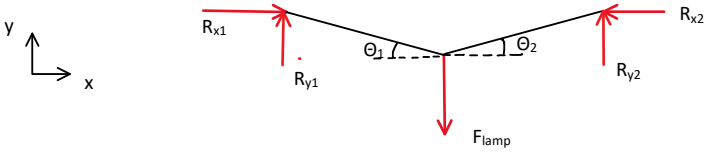
Assuming the brake is engaged



Note: A is pivot

Fig. P3.17 The brake

3.23 Draw a physical model and associated FBD of the cable supporting a street lamp (Fig. P3.19). Assume that the weight of the cable is negligible compared to the lamp.



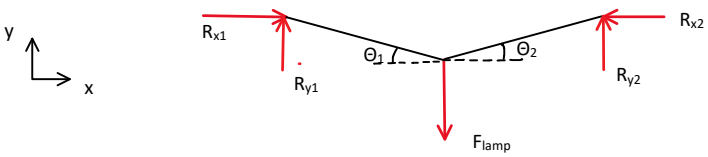


Fig. P3.19 Street lamp

2.1 Practice Problem Solutions

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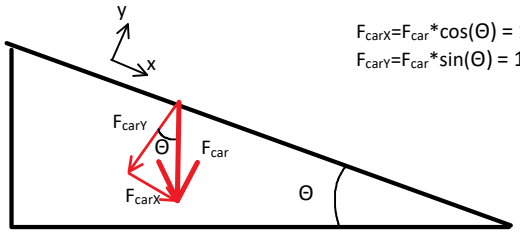
4.1 A car, weight $P = 15$ kN is parked on a slope of 10°. Calculate the parallel and normal to the slope components of the force acting between the car and ground. Consider car as a point.

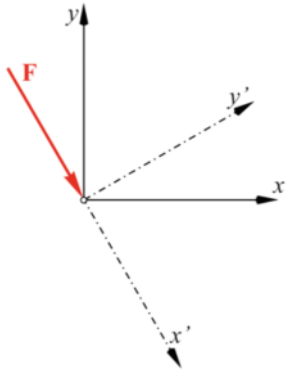


$F_{carX}=F_{car}*\cos(\Theta) = 15kN * .98 = 14kN$

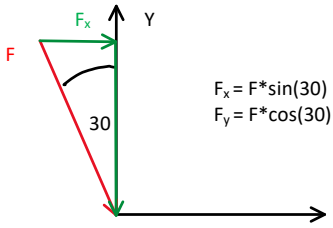
$F_{carY}=F_{car}*\sin(\Theta) = 15kN * .17 = 2.6kN$

Fig. P4.1

4.2 Force vector **F** forms a 30° angle with the y-axis. Determine its components in the coordinate system $x' - y'$.



Components of F with respect *x-y*



$F_x = F*\sin(30)$

$F_y = F*\cos(30)$

Components of F with respect *x'-y'*

Vector F apparently aligns with the x' axis. $F_x = F$

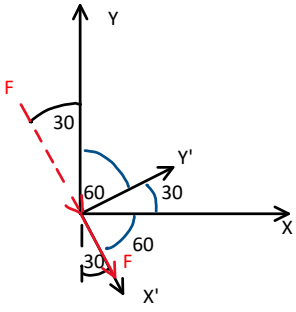
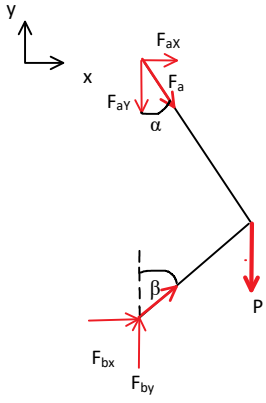


Fig. P4.2

4.13 200-N force P is acting on a frame. Calculate the components of P along struts AC and BC for the case $\alpha = 30°$ and $\beta = 45°$.



Info from FBD:

1. $\Sigma F_x = 0 = F_{ax} + F_{bx}$
2. $\Sigma F_y = 0 = -F_{ay} + F_{by} - P$

Breakdown of Forces:

3. $F_{ax} = F_a * \sin(\alpha)$
4. $F_{ay} = F_a * \cos(\alpha)$
5. $F_{bx} = F_b * \sin(\beta)$
6. $F_{by} = F_b * \cos(\beta)$

Manipulate equations into a useful form:

7. $F_a = F_{ax}/\sin(\alpha)$	From eq. 3
8. $F_{ax} = -F_{bx}$	From eq. 1
9. $F_{ay} = F_a*\cos(\alpha)$	From eq. 4
$= (F_{ax}/\sin(\alpha))*\cos(\alpha)$	sub eq. 7
$=(-F_{bx})*\cos(\alpha)/\sin(\alpha)$	sub eq. 8
$=-(F_b * \sin(\beta))*\cos(\alpha)/\sin(\alpha)$	sub eq. 5

Substitute eqs. until eq. 2 is in terms of consts and F_b:

Eq. 2

$0 = -F_{ay} + F_{by} - P$

Sub eq. 9 and eq. 6 into eq. 2

$-(-(F_b * \sin(\beta))*\cos(\alpha)/\sin(\alpha)) + (F_b * \cos(\beta)) - 200 = 0$

$(F_b * \sin(\beta)*\cos(\alpha)/\sin(\alpha)) + F_b*\cos(\beta) = 200$

$Fb*(\sin(\beta) + \cos(\beta)\cos(\alpha)/\sin(\alpha)) = 200$

$F_b = 200 / (\sin(45) + \cos(45)\cos(30)/\sin(30))$

$F_b =$ **104N**

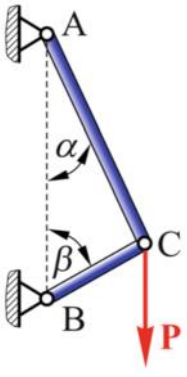
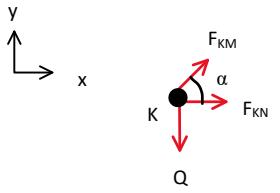


Fig. P4.13

Use F_b to find F_a

$F_{bx} = F_b * \cos(\beta) = 104*\sin(45)=73$	eq. 5
$F_{ax}=-F_{bx}=-73$	eq. 8
$F_a= -F_{ax}/\sin(30) = -73/\sin(30)=$ **-146N**	eq. 7

4.15 60-lb force Q is acting on a frame. Calculate the components of Q along struts KN and KM for the case of $\alpha = 30°$ and $\beta = 60°$.



At point K

1. $\Sigma f_y = 0$
   $-Q + F_{KM}*\sin(30) = 0$
   $Q = F_{KM}*\sin(30)$
   $60 = F_{KM}*\sin(30)$
   $F_{KM} = 60 / \sin(30)$
   $F_{KM} = 120$ lb

2. $\Sigma F_x = 0$
   $F_{KN} + F_{KM}*\cos(30) = 0$
   $-F_{KN} = F_{KM}*\cos(30)$
   $-F_{KN} = 120*\cos(30)$
   $F_{KN} = -103.92$ lb

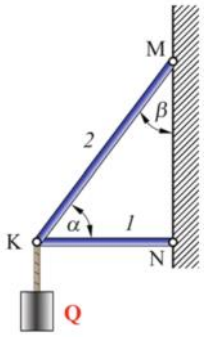
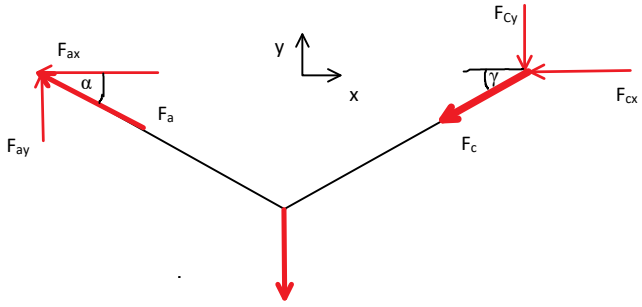


Fig. P4.15

4.24 A street light is suspended by two cables. Find the tension in each cable, if weight **P** of the light is 50 N, length of cable AB = BC = 6 m, and distance BD = 0.1 m.



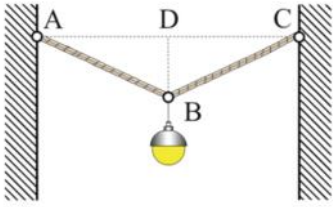


Fig. P4.24

Use Geometry to find angle:
$\alpha = \sin^{-1}(DB/AB) = \sin^{-1}(.1/6) = .954°$
$\Gamma = \sin^{-1}(DB/BC) = \sin^{-1}(.1/6) = .954°$

Write info from FBD:
1. $\Sigma F_x = 0 = -F_{ax} - F_{cx}$
2. $\Sigma F_y = 0 = F_{ay} - F_{cy} - P$

Force decomposition:
3. $F_{ax} = F_a * \cos(\alpha)$
4. $F_{ay} = F_a * \sin(\alpha)$
5. $F_{cx} = F_c * \cos(\gamma)$
6. $F_{cy} = F_c * \sin(\gamma)$

Manipulate equations into a useful form
7. $F_a = F_{ax}/\cos(\alpha)$ From eq. 3
8. $F_{ax} = -F_{cx}$ From eq. 1
9. $F_{ay} = F_a*\sin(\alpha)$ eq. 4
   $= (F_{ax}/\cos(\alpha))*\sin(\alpha)$ sub eq. 7
   $= (-F_{cx})*\sin(\alpha)/\cos(\alpha)$ sub eq. 8
   $= -(F_c * \cos(\alpha))*\tan(\alpha)$ sub eq. 5

Use substitution until eq. 2 is in terms of F_c and consts
$0 = (-F_c * \cos(\alpha))*\tan(\alpha) - (F_c*\cos(\gamma)) - P$ sub eq. 9 and eq. 6 into eq. 2
$P = F_c(-\cos(\alpha))*\tan(\alpha) - \cos(\gamma))$
$P/(-\cos(\alpha))*\tan(\alpha) - \cos(\gamma)) = F_c$
$F_c = 50/(-\cos(.954)*\tan(.954) - \cos(.954)) =$ **-49.2N**

use value of F_c in eq. 5 to find F_a
$F_{cx} = F_c*\cos(\gamma) = -49.2*\cos(.954) = -49.19$
$F_{ax} = -F_{cx} = 49.19$
$F_a = F_{ax}/\cos(\alpha) = 49.19/\cos(.954) =$ **49.2N**

2.2 Practice Problems

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(39) How much average power in kilowatts and horsepower is required to lift a block of 100 kg to a height of 10 m in 30 s?

$P=Fd/t = mgh/t = 100kg * 9.8m/s^2 * 10m / 30s = 327W = .327kW$

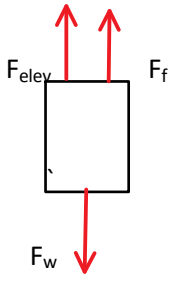
$327W * (1hp/746W) = .42hp$

(40) At 30 piasters (Egyptian pound = 100 Piaster) per kilowatt-hour of electricity, what is the cost of operating a 5-hp motor for 2 h?

5hp * (745.7 W / 1hp) = 3728.5 W = 3.73kW
Energy (E) = P * t = 3.73kW*2h = 7.46 kWh

Cost = 7.46 kWh * 30(piaster/kWh) * (1 Egyptian pound / 100 piaster) = 2.23 Egyptian pounds

(41) An elevator fully loaded with passengers has a mass $M = 2{,}000$ kg. As the elevator descends, an almost constant frictional force $f = 4{,}000$ N acts against its motion. What power must be delivered by the motor to descend the elevator at: (a) a constant speed v of 4 m/s, and (b) a constant acceleration a of 1.5 m/s^2 that produces a speed $v = at$?



Ignore b. It does not deal with statics.
Note that two forces are acting on the elevator: gravity and friction
Since the elevator moves down, $F_{friction}$ points up.

a) For a constant a = 0. Therefore ΣF=0
$F_W = mg = 2000kg*9.8m/s^2 = 19{,}600N$
$\Sigma F=0=F_{elev}+Ff-F_w$
$F_{elev} = F_w - F_f = 19{,}600 - 4{,}000 = 15{,}600$ N
$P=Fv = 15{,}600N * 4m / 1s =$ **62,400W**

(43) A car generates 20 hp when traveling at a constant speed of 100 km/h. What is the total resistive force that acts on the car?

1hp = 745.7 W = 745.7 Nm/s

P = 20hp = 14914 Nm/s
v = d/t = 100km/h*(1000m/1km) * (1h/3600s) = 27.78 m/s

P = F * v
F = P/v = 14914W / 27.78s = 536.86 N