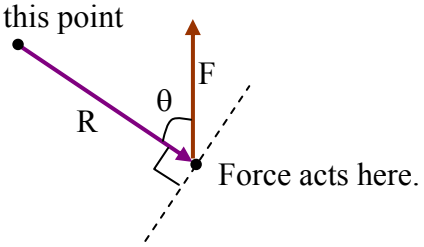
Torque Exercises - Solutions

We have three methods for calculating torque about a particular point.

A. Want torque about this point

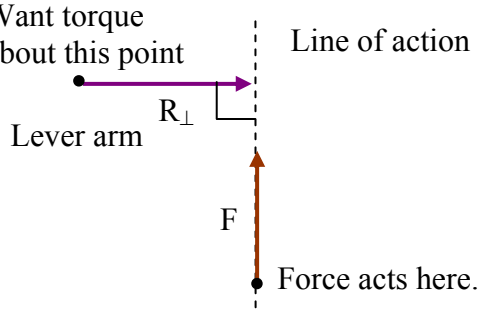


$\tau = rF_\perp = rF\sin\theta$

Note: $F_\perp$ means the component of F perpendicular to R – not the vertical component of F.

Use this method if both R and θ are easy to find.

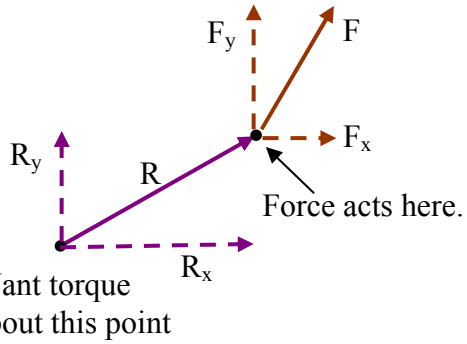
B. Want torque about this point



$\tau = R_\perp F$

Use this method if the lever arm is easy to find.

C.



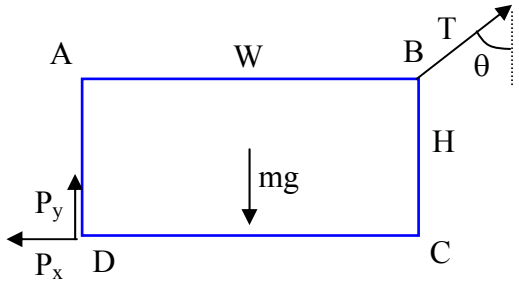
$$\vec{\tau} = \vec{R} \times \vec{F}$$
$$= (\hat{i}R_x + \hat{j}R_y) \times (\hat{i}F_x + \hat{j}F_y)$$
$$= \hat{k}(R_xF_y - R_xF_y)$$

Use if $\vec{R}$ and $\vec{F}$ are easy to break into components.

Equivalent to using the leverarm approach for each component of $\vec{F}$.

Solutions

(a)



Point A

Force	Method	Torque
T	A	$+WT\sin\theta$
mg	B	$-\frac{1}{2}Wmg$
P_y	B	0
P_x	B	$-HP_x$

Point B

Force	Method	Torque
T	A	0
mg	B	$+\frac{1}{2}Wmg$
P_y	B	$-WP_y$
P_x	B	$-HP_x$

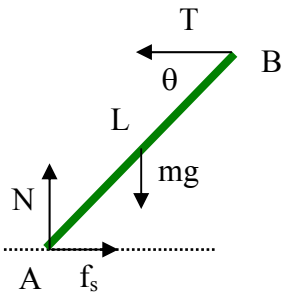
Point C

Force	Method	Torque
T	A	$-T\cos\theta$
mg	B	$+\frac{1}{2}Wmg$
P_y	B	$-WP_y$
P_x	A	0

Point D

Force	Method	Torque
T	C	$+WT\sin\theta - HT\cos\theta$
mg	B	$-\frac{1}{2}Wmg$
P_y	B	0
P_x	B	0

(b)



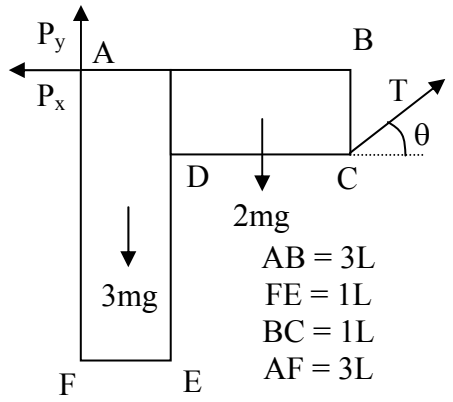
Point A

Force	**Method**	**Torque**
T	A	+LTsinθ
mg	B	–½Lcosθ mg
N	A	0
f_s	a	0

Point B

Force	**Method**	**Torque**
T	A	0
mg	B	+½Lcosθ mg
N	B	–LcosθN
f_s	B	+Lsinθf_s

(c)



Point A

Force	**Method**	**Torque**
T	C	$+3LT\sin\theta + LT\cos\theta$
2mg	B	$-2L\cdot 2mg$
3mg	B	$-\frac{1}{2}L\cdot 3mg$
P_y	A	0
P_x	A	0

Point B

Force	**Method**	**Torque**
T	A	$+LT\cos\theta$
2mg	B	$+L\cdot 2mg$
3mg	B	$+\frac{5}{2}L\cdot 3mg$
P_y	B	$-3LP_y$
P_x	A	0

Point C

Force	**Method**	**Torque**
T	A	0
2mg	B	$+L\cdot 2mg$
3mg	B	$+\frac{5}{2}L\cdot 3mg$
P_y	B	$-3LP_y$
P_x	B	$+LP_x$

Point D

Force	**Method**	**Torque**
T	A	$+2LT\sin\theta$
2mg	B	$-L\cdot 2mg$
3mg	B	$+\frac{1}{2}L\cdot 3mg$
P_y	B	$-LP_y$
P_x	B	$+LP_x$

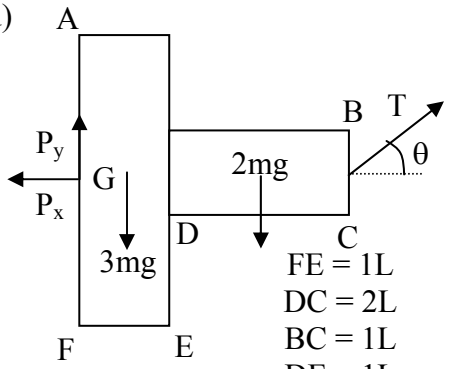
Point E

Force	**Method**	**Torque**
T	C	$+2LT\sin\theta - 2LT\cos\theta$
2mg	B	$-L\cdot 2mg$
3mg	B	$+\frac{1}{2}L\cdot 3mg$
P_y	B	$-LP_y$
P_x	B	$+3LP_x$

Point F

Force	Method	Torque
T	C	$+3LT\sin\theta - 2LT\cos\theta$
2mg	B	$-2\cdot 2mg$
3mg	B	$-\frac{1}{2}L\cdot 3mg$
P_y	A	0
P_x	B	$+3LP_x$

(d)



FE = 1L
DC = 2L
BC = 1L
DE = 1L

Point A

Force	Method	Torque
T	C	$+3LT\sin\theta + {}^{3}/_{2}LT\cos\theta$
2mg	B	$-2L\cdot 2mg$
3mg	B	$-\frac{1}{2}L\cdot 3mg$
P_y	A	0
P_x	B	${}^{-3}/_{2}LP$

Point B

Force	Method	Torque
T	A	$+\frac{1}{2}LT\cos\theta$
2mg	B	$+L\cdot 2mg$
3mg	B	$+{}^{5}/_{2}L\cdot 3mg$
P_y	A	$-3LP_y$
P_x	A	$-\frac{1}{2}LP_x$

Point C

Force	Method	Torque
T	A	$-\frac{1}{2}LT\cos\theta$
2mg	B	$+L\cdot 2mg$
3mg	B	$+{}^{5}/_{2}L\cdot 3mg$
P_y	A	$-3LP_y$
P_x	A	$+\frac{1}{2}LP_x$

Point D

Force	Method	Torque
T	C	$+2LT\sin\theta - \frac{1}{2}LT\cos\theta$
2mg	B	$-L\cdot 2mg$
3mg	B	$+\frac{1}{2}L\cdot 3mg$
P_y	A	$-LP_y$
P_x	A	$+\frac{1}{2}LP_x$

Point E

Force	Method	Torque
T	C	$+2LT\sin\theta - {}^{3}/_{2}LT\cos\theta$
2mg	B	$-L\cdot 2mg$
3mg	B	$+\frac{1}{2}L\cdot 3mg$
P_y	B	$-LP_y$
P_x	B	$+{}^{3}/_{2}LP_x$

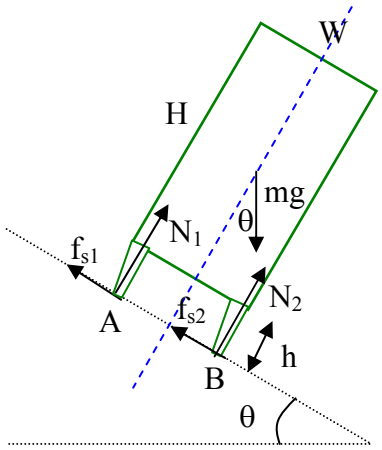
Point F

Force	Method	Torque
T	C	$+3LT\sin\theta - {}^{3}/_{2}LT\cos\theta$
2mg	B	$-2L\cdot 2mg$
3mg	B	$-\frac{1}{2}L\cdot 3mg$
P_y	A	0
P_x	B	$+{}^{3}/_{2}LP_x$

Point G

Force	Method	Torque
T	A	$+3LT\sin\theta$
2mg	B	$-L\cdot 2mg$
3mg	B	$-\frac{1}{2}L\cdot 3mg$
P_y	A	0
P_x	A	0

(e)



Rotate your axis to line up with the incline!

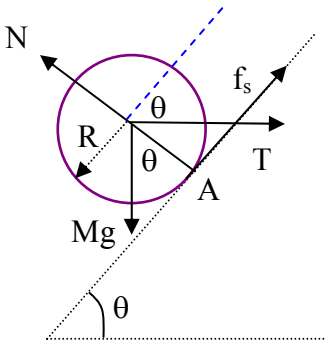
Point A

Force	Method	Torque
mg	C	$-\frac{1}{2}Wmg\cos\theta - (h+\frac{1}{2}H)mg\sin\theta$
N_1	A	0
f_{s1}	A	0
N_2	B	$+\frac{1}{2}WN_2$
f_{s2}	A	0

Point B

Force	Method	Torque
mg	C	$+\frac{1}{2}Wmg\cos\theta - (h+\frac{1}{2}H)mg\sin\theta$
N_1	B	$-WN_1$
f_{s1}	A	0
N_2	A	0
f_{s2}	A	0

(f)



Point A

Force	Method	Torque
Mg	A	$+RMg\sin\theta$
N	B	0
f_s	B	0
T	A	$-RT\sin\theta$