AP Physics - Unit 7

Tipper #7 - Unit 7 - KEY

#1 E > A = C > D > B

$\tau = F r_\perp$ * Force times perpendicular distance

same mass ∴ All same $F = mg$

A

$\tau = F r_\perp$

$= F r \cos 30$

$= .86 F r$

B

$\tau = F r/2$

$\tau = \frac{1}{2} F r$

C

$\tau = F r \sin(60)$

$\approx .86 F r$

D

$\tau = F r \cos 45$

$\tau \approx .71 F R$

e

$\tau = F r$

#2 Answer: C > A > D > B.

The larger the moment of inertia of the system the more difficult it will be to rotate it. The moment of inertia for each one is the sum of the product of each point mass times its distance from the axis of rotation. Since they all have seven point masses to sum the farther more masses are from the axis the larger the moment of inertia.

$I = mr^2$

A) (~ # of masses, ~ r)

$I = 3(1)^2 + 2(2)^2 + 1(3)^2$

$= 3 + 8 + 9$

$I_A = 20$

B)

$I_B = 5(1)^2 + 2(2)^2$

$= 5 + 8$

$I_B = 13$

C)

$I_C = 2(1)^2 + 2(2)^2 + 3(3)^2$

$= 2 + 8 + 27$

$I_C = 37$

D) $I_D = 4(1)^2 + 3(2)^2$

$= 4 + 12$

$I_D = 16$

Tipper #2 - Unit 7 - KEY

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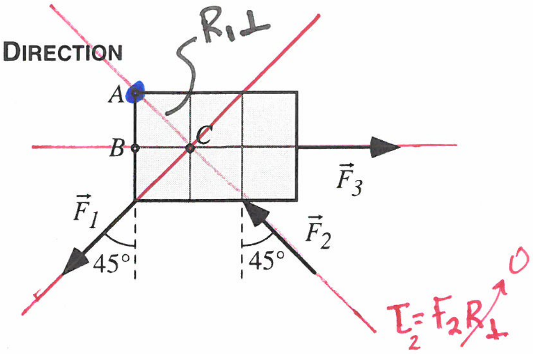
#3 B6-QRT07: Three Equal Forces Applied to a Rectangle—Net Torque Direction



Three forces of equal magnitude are applied to a 3-m by 2-m rectangle. Forces $\vec{F}_1$ and $\vec{F}_2$ act at 45° angles to the vertical as shown, while $\vec{F}_3$ acts horizontally.

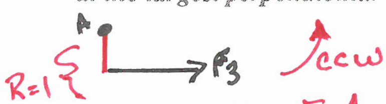
(a) Is the net torque about point *A* (i) *clockwise*, (ii) *counterclockwise*, or (iii) *zero*? _____

Explain your reasoning.

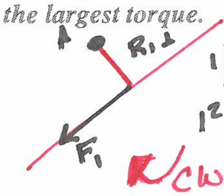
Red - line of Action

Answer: Clockwise.

Since the line of action for F_2 is through point A, F_2 creates no torque about point A. The line of action for force F_3 passes through point B, 1 meter away from P. The shortest distance from A to the line of action for force F_1 is 1.41 meters, the distance from point A to point C. Force F_1 will produce a clockwise torque about point A, and force F_3 will produce a counterclockwise torque about point A. Since all of the forces are equal, the force acting at the largest perpendicular distance generates the largest torque.



$\tau_3 = F_3 1$



$1^2 + 1^2 = R_1^2$

$R_1 = 1.41$

$\tau_1 = F R_1$

τ_1 1.41 F

$\tau_1 > \tau_3$

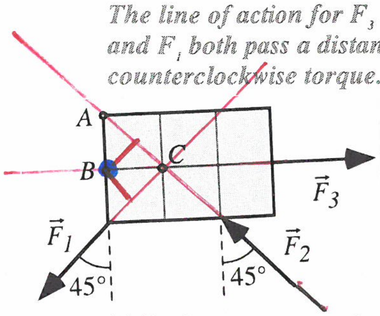
∴ CW

(b) Is the net torque about point *B* (i) *clockwise*, (ii) *counterclockwise*, or (iii) *zero*? _____

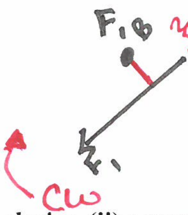
Explain your reasoning.

Answer: Zero.

The line of action for F_3 is through point B, so F_3 creates no torque about point B. The line of action for forces F_2 and F_1 both pass a distance of 0.707 meters from point B, but one creates a clockwise torque about B and one a counterclockwise torque. So the torques due to these two forces will cancel, and the net torque about B is zero.



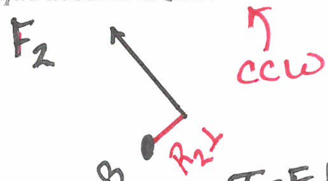
$F_3 R_3 = \tau_3$ (0)



$\tau_1 = F R_1 \perp$

R_1 ½ 1.41

$\tau_1 = .707$ F



$\tau_2 = F R_2$

$R_2 = \frac{1}{2} R_1$

$\tau_2 = .707F$

$\tau_1 = \tau_2$

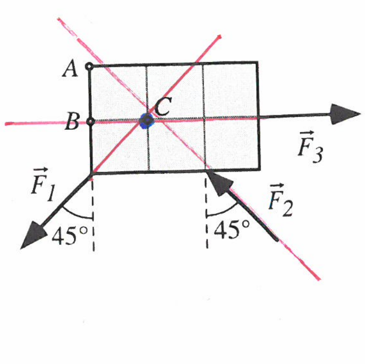
∴ 0

(c) Is the net torque about point *C* (i) *clockwise*, (ii) *counterclockwise*, or (iii) *zero*? _____

Explain how you determined your answer.

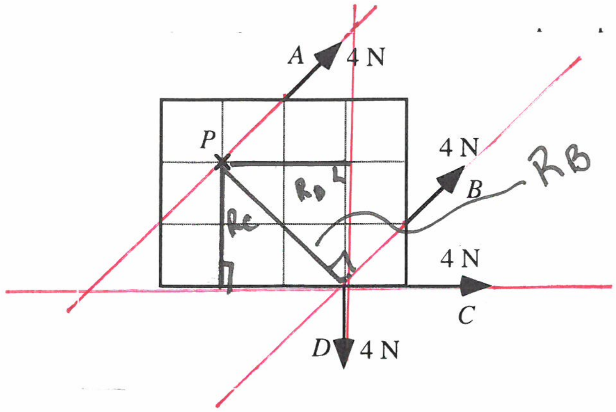
Answer: Zero.

The line of action for all forces pass through point C, so the torque due to each force is zero, and the net torque is also zero.



Tipper #2- Unit 7

#4



— Line of Action

A goes Thru P ∴ $\tau = 0$

B

C & D exert equal Torques in opposite directions $R_c = R_D = 2$

B Force ↗ ccw

#5 It will Rotate Clockwise, since the Clockwise torque due to the 3 Keys is greater than the torque due to the 2 Keys

#6

Answer: D > A > C > B.

The torque will be the product of the tension in the string, which will be equal to the magnitude of the hanging weight since the systems remain at rest, times the radius of the disk, which is half of the diameter given in each figure.

A

$\tau = FR$

$= (.5\,kg)(9.8\,m/s^2)(.1\,m)$

$= 0.49\ N\cdot m$

B

$\tau = FR$

$= (.2\,kg)(9.8\,m/s^2)(.05\,m)$

$= 0.098\ N\cdot m$

C

$\tau = FR$

$= (.5\,kg)(9.8\,m/s^2)(.05\,m)$

$= 0.245\ N\cdot m$

D

$\tau = FR$

$= (.8\,kg)(9.8\,m/s^2)(.1\,m)$

$= 0.78\ N\cdot m$

D > A > C > B

Tipper #2 - Unit 7 - KEY

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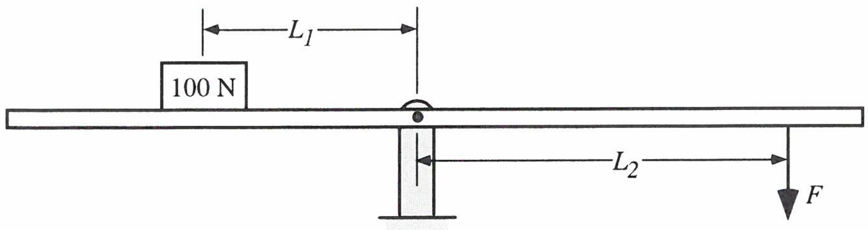
B6-LMCT20: Horizontal Pivoted Board with Load II—Force to Hold Board

#7

A 100-N weight is placed on a massless board a distance L_1 to the left of frictionless pin. A vertical downward force F is applied to the other side of the board a distance of L_2 from the pin as shown. The system is at rest.



Identify from choices (i)–(v) how each change described below will affect the magnitude of the applied force (F) on the right side of the board needed to keep the system in equilibrium.

Compared to the case above, this change will:

(i) ***increase*** the magnitude of the support force (F) on the board.
(ii) ***decrease*** the magnitude of the support force (F) on the board but not to zero.
(iii) ***decrease*** the magnitude of the support force (F) on the board **to zero**.
(iv) ***have no effect*** on the magnitude of the support force (F) on the board.
(v) *have an* ***indeterminate*** effect on the magnitude of the support force (F) on the board.

Each of these modifications is the only change to the initial situation shown in the diagram above.

(a) The 100-N weight is moved to a position closer to the pin. _____
Explain your reasoning.

Answer: (ii). This will reduce the torque due to the 100 N weight.

(b) The support force (F) is moved to a position closer to the pin. _____
Explain your reasoning.

Answer: (i). A smaller moment arm requires a larger force to produce the same torque.

(c) The weight is decreased to 50 N. _____
Explain your reasoning.

Answer: (ii). This will reduce the torque to be balanced.

(d) The support force (F) is moved to the right end of the board. _____
Explain your reasoning.

Answer: (ii). Increasing the moment arm will reduce the force required.

(e) The board is made longer but the support force (F) remains at the same location. _____
Explain your reasoning.

Answer: (iv). This doesn't change either torque.

(f) The 100-N weight and the support force (F) are both moved to positions closer to the pin. _____
Explain your reasoning.

Answer: (v). *We would need to know how the new ratio of the distances compared to the old ratio to be able to determine the effect on the magnitude of F.*

#8 *Answer: Greater than.*

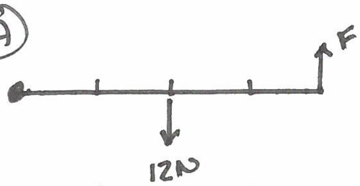
The net torque about the balancing point of the rod is zero, since the rod has no angular acceleration. The weight of the rod to the left of the balancing point creates a counterclockwise torque about that point, and the weight of the rod to the right creates a clockwise torque. The magnitudes of these torques must be equal for the net torque to be zero. The weight of the left side of the rod (the handle) acts at the center of mass of the left side, and the weight of the right side acts at the center of mass of the right side. Since the right side is longer than the left, the center of mass of the right side is further away from the dashed line than the center of mass of the left side. For the torques to be equal, the weight of the left side must be greater to compensate for the smaller perpendicular distance.

#9 E = F > C > A = D > B

All systems are in Equilibrium, so in Each case the 2 Torque's About the pin must Be Zero. $\tau_{weight} = \tau_{force}$
cw ccw

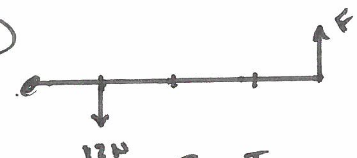
Total Length (R) = 2
marks = .5 m

(A)



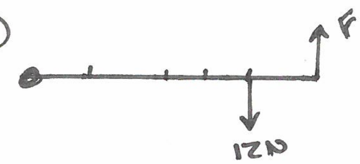
$\tau = Fr$ $\tau = \tau$
$12(1m) = 2F$
$F = 6$

(B)



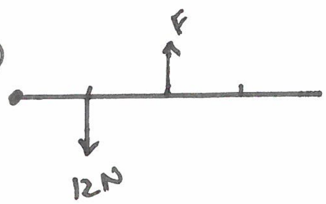
$\tau = \tau$
$12(.5m) = 2F$
$F = 3$

(C)



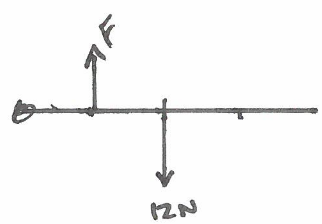
$\tau = \tau$
$12(1.5m) = 2F$
$F = 9$

(D)



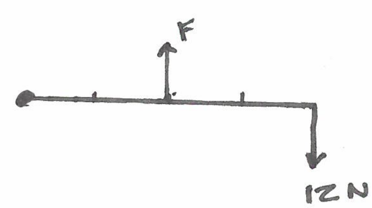
$\tau = \tau$
$12(.5) = 1F$
$F = 6$

(E)



$\tau = \tau$
$12(1) = .5F$
$F = 24$

(F)



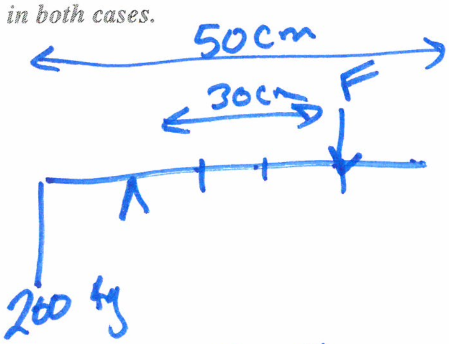
$\tau = \tau$
$12(2) = 1F$
$F = 24$

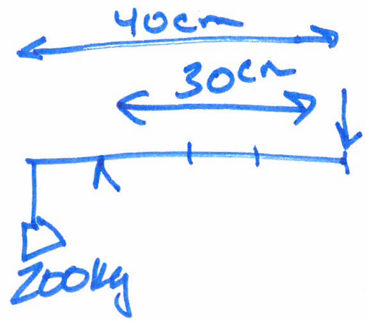
Tipper #2 - Unit 7

#10

Answer: The same in both cases.

In each case, the tension in the cable is equal to the weight of the hanging mass, about 2000 N. In both cases, the distance between the line of action of the weight of the hanging mass and the fulcrum is one-third the distance between the line of action of the applied force F and the fulcrum. Since there is no rotational acceleration, the net torque must be zero in each case, so the clockwise torque due to the applied force F must be equal in magnitude to the counterclockwise torque due the cable tension. The applied force must be one-third the weight in both cases.





$\tau = \tau$

$200kg(10cm) = 30cm\,F$

$F = 66.7$

$200kg(10cm) = 30cm\,F$

$F = 66.7$