

Phys171 - Fri 4/13

HW 13 DUE April 20 - THIS IS LONG

3rd midterm on Mon Apr 23

FINAL EXAM:

PHY 0405 Fri, May 18 8:00 am - 10:00 am

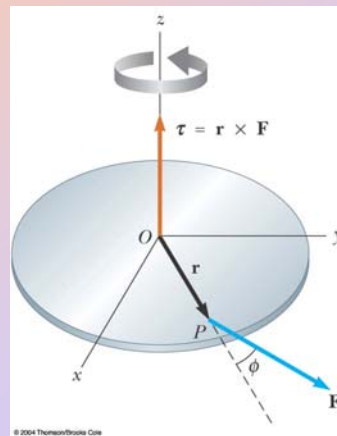
Chapter 13 - Rotation

Torque: tendency of a force to generate rotation an object about some axis

Torque vector $\tau = \mathbf{r} \times \mathbf{F}$
(vector product)

Direction: perpendicular to the plane formed by the position vector and the force vector (right-hand rule)

Magnitude: $r F \sin(\theta)$



Vector product example

Given the force

$$\mathbf{F} = (2.00\hat{\mathbf{i}} + 3.00\hat{\mathbf{j}}) \text{ N}$$

$$\mathbf{r} = (4.00\hat{\mathbf{i}} + 5.00\hat{\mathbf{j}}) \text{ m}$$

$$\boldsymbol{\tau} = ?$$

$$\begin{aligned}\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F} &= [(4.00\hat{\mathbf{i}} + 5.00\hat{\mathbf{j}})\text{N}] \times [(2.00\hat{\mathbf{i}} + 3.00\hat{\mathbf{j}})\text{m}] \\ &= [(4.00)(2.00)\hat{\mathbf{i}} \times \hat{\mathbf{i}} + (4.00)(3.00)\hat{\mathbf{i}} \times \hat{\mathbf{j}} \\ &\quad + (5.00)(2.00)\hat{\mathbf{j}} \times \hat{\mathbf{i}} + (5.00)(3.00)\hat{\mathbf{j}} \times \hat{\mathbf{j}}] \\ &= 2.0\hat{\mathbf{k}} \text{ N} \cdot \text{m}\end{aligned}$$

Properties of the Vector Product

The order in which the vectors are multiplied is important

$$\mathbf{A} \times \mathbf{B} = -\mathbf{B} \times \mathbf{A}$$

If \mathbf{A} is parallel to \mathbf{B} ($\theta = 0^\circ$ or 180°), then $\mathbf{A} \times \mathbf{B} = 0$

- For example, $\mathbf{A} \times \mathbf{A} = 0$

Two ways to understand the torque

Magnitude: $\tau = r F \sin \phi$

(1) $\tau = F d$

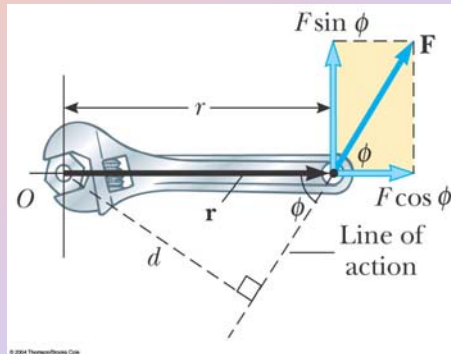
d : *perpendicular* distance from the axis of rotation to a line drawn along the direction of the force

$$d = r \sin \phi$$

(2) $\tau = F_t r$

F_t : tangential part of force

$$F_t = F \sin \phi$$



You are using a wrench and trying to loosen a rusty nut. Which of the arrangements shown is most effective in loosening the nut? What is the most efficient arrangement? © Mazur

