

UEQ #1: How can the rotational motion be described in a measurable and quantitative way?

Unit 8 Rotational Motion



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UEQ: How can rotational motion be described, measured, and quantified?

VOCABULARY

- Radians
- Angular Displacement
- Angular Velocity
- Angular Acceleration
- Frequency
- Period
- Axis of Rotation
- Moment Arm
- Torque
- Right-Hand Rule
- Static Equilibrium
- Cantilever
- Stable Equilibrium
- Unstable Equilibrium
- Neutral Equilibrium
- Moment of Inertia
- Rotational Inertia
- Rotational Kinetic Energy
- Angular Momentum

UEQ: What factors affect changes in an object's rotational motion?

LESSON 3

Rotational Motion
Torque

UEQ: How can rotational motion be described, measured, and quantified?

Rotational Motion: Torque

EQ(s): How do you calculate the torque on an object?; How are torque and force related?

Start: Why do bicyclists use clipless pedals on their bike? What type of motion maximizes their pedaling efficiency?

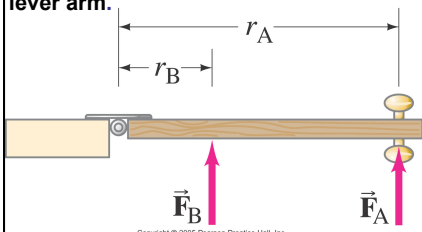


How do you calculate the torque on an object?; How are torque and force related?

8-4 Torque

To make an object **start rotating**, a **force** is needed; the **position** and **direction** of the force matter as well.

The **perpendicular distance** from the axis of rotation to the line along which the force acts is called the **lever arm**.



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How do you calculate the torque on an object?; How are torque and force related?

8-4 Torque



(a)



(b)

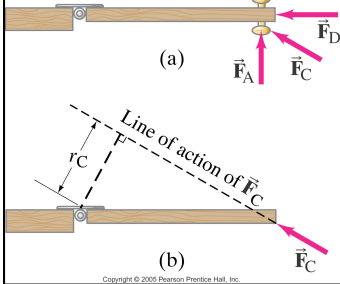
A longer lever arm is very helpful in rotating objects.

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How do you calculate the torque on an object?: How are torque and force related?

8-4 Torque?

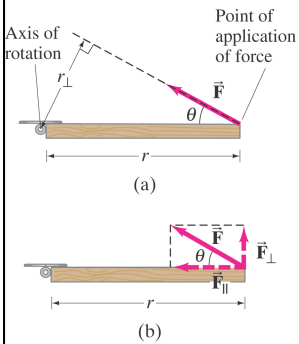
Here, the lever arm for F_A is the distance from the knob to the hinge; the lever arm for F_D is zero; and the lever arm for F_C is as shown.



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How do you calculate the torque on an object?: How are torque and force related?

8-4 Torque

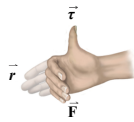


The torque is defined as:

$$\tau = r_{\perp} F \quad (8-10a)$$

$$\tau = r \times F$$

$$\tau = rF \sin \theta$$



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How do you calculate the torque on an object?: How are torque and force related?

PRACTICE PROBLEM

How much torque is applied on a single bicycle crank arm if a force of 500 N is applied on a 0.170 m crank at an angle of 30°?

Identify what you are trying to find:

Find _____.

Identify the given information:

$r =$ _____

$F =$ _____

$\theta =$ _____

Write down the formula that contains r , F , and θ :

If necessary, algebraically solve for the unknown.

Substitute the numbers and units into the problem:

Write the answer with units:



How do you calculate the torque on an object?: How are torque and force related?

PRACTICE PROBLEM

How much torque is applied on a single bicycle crank arm if a force of 500 N is applied on a 0.170 m crank at an angle of 30°?

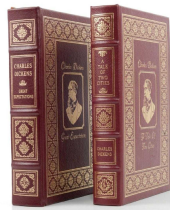
- Identify what you are trying to find:
Find τ .
- Identify the given information:
 $r = 0.170 \text{ m}$
 $F = 500 \text{ N}$
 $\theta = 30^\circ$
- Write down the formula that contains r , F , and θ :
 $\tau = r \times F = r F \sin \theta$
- If necessary, algebraically solve for the unknown.
- Substitute the numbers and units into the problem:
 $\tau = (0.170 \text{ m}) (500 \text{ N}) \sin 30^\circ$
- Write the answer with units: $\tau = 42.5 \text{ N}\cdot\text{m}$



How can rotational inertia and angular velocity of an object be represented in terms of its angular momentum and kinetic energy?

Reading Enrichment

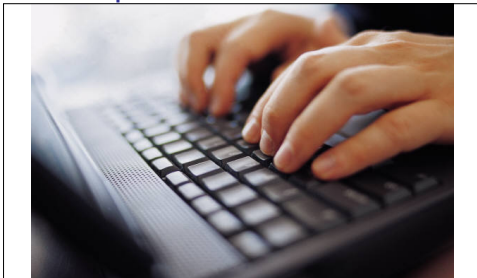
- Does screwdriver length matter?
– <https://physics.stackexchange.com/questions/149314/does-screwdriver-length-matter>
- Perfect Pedaling: Get a Better Pedal Stroke
– <https://www.bicycling.com/training/a20021262/pedaling-mechanics/>
- 8 Ways to Smooth Out Your Pedal Stroke
– <https://www.bicycling.com/training/q20009934/8-ways-to-smooth-out-your-pedal-stroke/>



How do you calculate the torque on an object?: How are torque and force related?

COMPUTER LAB: PhET Torque

- <http://phet.colorado.edu/en/simulation/torque>
- Return computers to the counter/cart.



How do you calculate the torque on an object?; How are torque and force related?

WebAssign/Lab Time

- Work on WebAssign PIM Ch.08C – Torque Home
- Final Copy Criteria
 - State the problem (Ex. Find displacement)
 - Draw a picture/diagram
 - Provide a list or table of all given data (Ex. $\Delta t = 2 \text{ s}$)
 - Solve the problem symbolically (Ex. $v = \Delta x / \Delta t \rightarrow \Delta x = v \Delta t$)
 - Plug in numbers and units to obtain answer.
(Ex. $\Delta x = (5 \text{ m/s})(2 \text{ s}) = 10 \text{ m}$)
- Notes about WebAssign:
 - Positive vs. negative answers (Try a negative sign)
 - Look at the final unit (hours or minutes or seconds)

How do you calculate the torque on an object?; How are torque and force related?

Summary

- Answer the Essential Questions.
- Ticket out the Door:
 - What is the formula for torque?
 - What lever arm angle maximizes the torque?
 - What motion maximizes a bicyclist's pedaling efficiency?
- HW:
 - PhET Torque (Questions and Conclusions)
 - WebAssign PIM Ch.08C – Torque