ME 20N: Haptics: Engineering Touch
Autumn 2017

Week 2: Haptic device design and kinematics

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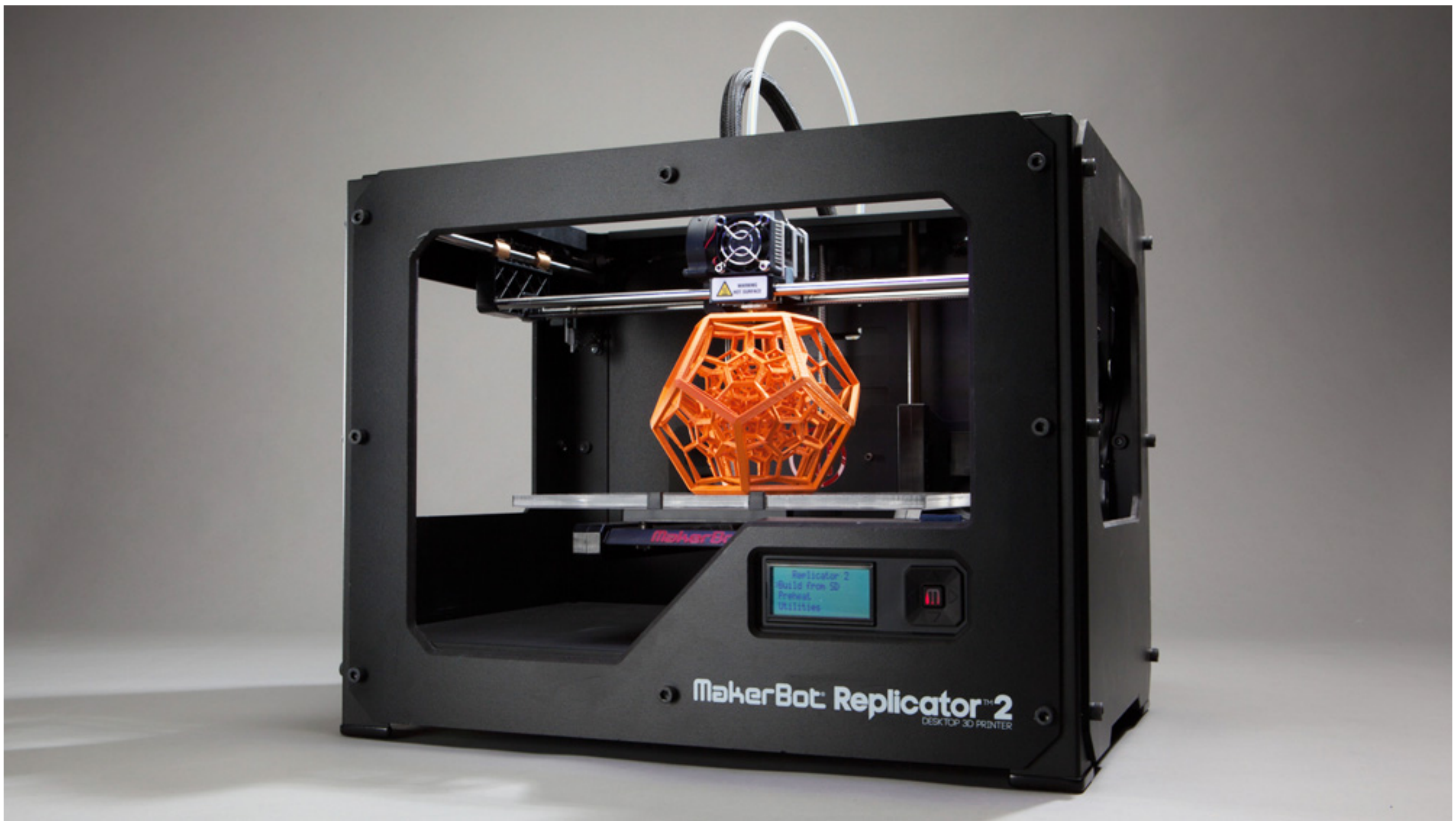
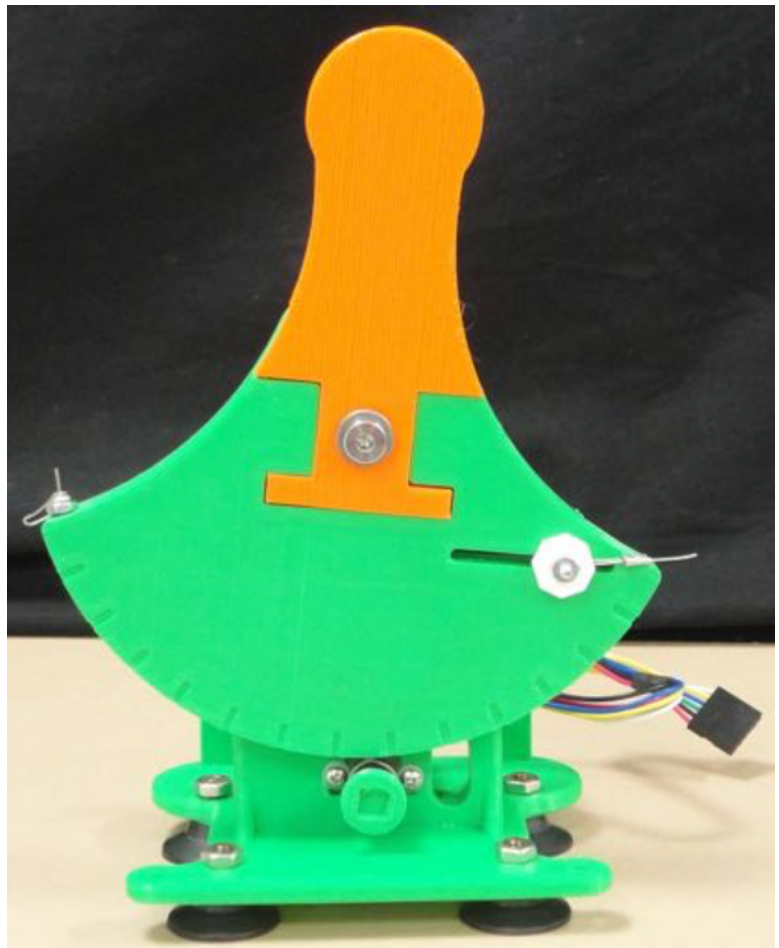
3D printing introduction

by Melisa Orta Martinez, Kaitlyn Gee, and Tyler Cloyd



Hapkit introduction



Kinematics

Kinematics describes the motion of points, bodies, or groups of bodies

Kinematic analysis does not require any knowledge about what forces cause the motion

Kinematics is a branch of classical mechanics

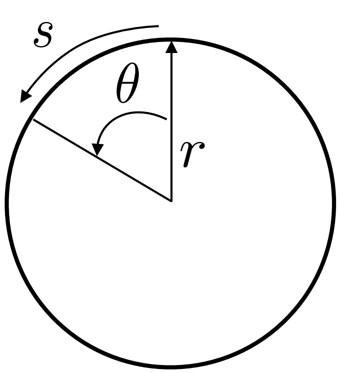
Our goal is to find equations that describe the kinematics of a mechanism

Kinematic Relationships

In this class, a key kinematic relationship is:

$$s = r\theta$$

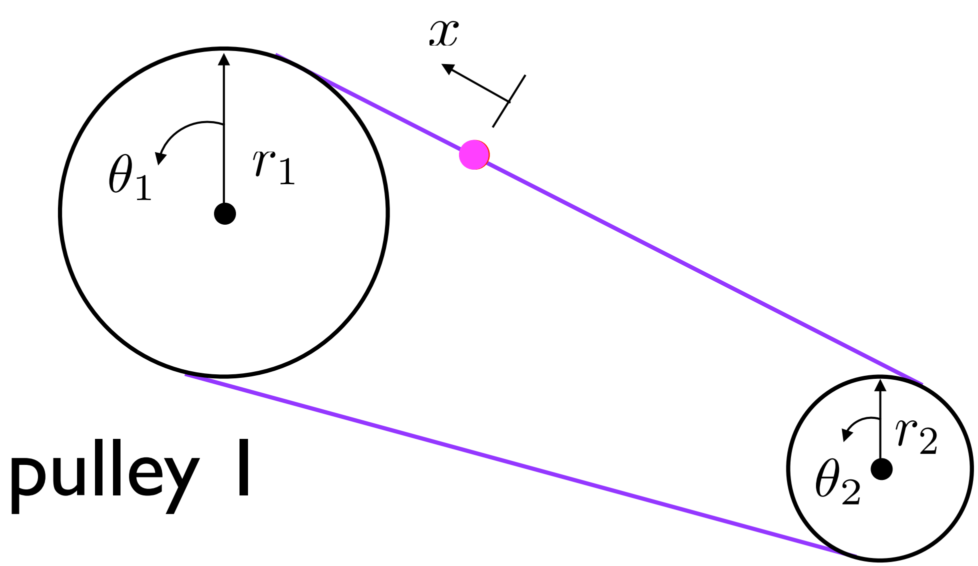
arc length — radius — angle (in radians!)



π radians = 180 degrees

Kinematic Relationships

Belt-on-pulleys example



$$s_1 = r_1\theta_1$$

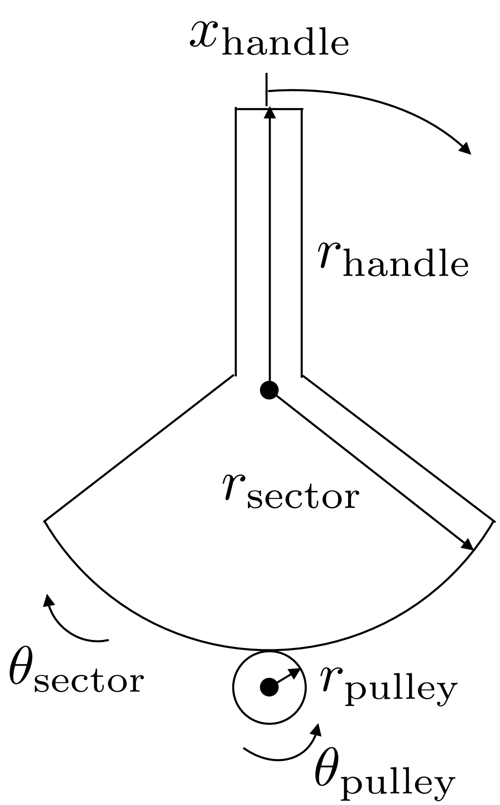
$$s_2 = r_2\theta_2$$

$$x = s_1 = s_2$$

$$\theta_2 = \frac{r_1}{r_2}\theta_1$$

Q: if $r_1 > r_2$, which pulley rotates more?

Hapkit Kinematics: Motions



$$r_{\text{pulley}}\theta_{\text{pulley}} = r_{\text{sector}}\theta_{\text{sector}}$$

$$x_{\text{handle}} = r_{\text{handle}}\theta_{\text{sector}}$$

$$\Downarrow$$

$$x_{\text{handle}} = \frac{r_{\text{handle}} r_{\text{pulley}}}{r_{\text{sector}}}\theta_{\text{pulley}}$$

Q: The sensor measures θ_{pulley}. Would you make r_{handle} larger or smaller to more accurately compute x_{handle}?

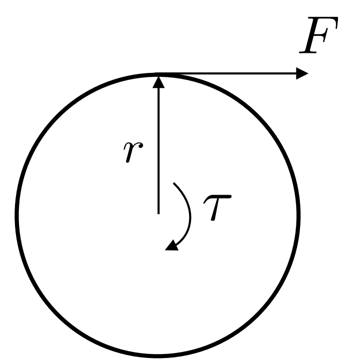
Force-torque Relationships

Torque, or moment, is the tendency of a force to rotate an object.

If a force is perpendicular to r (the vector connecting the point about which the torque acts to the point at which the force is applied), this is the scalar relationship between force and torque:

$$\tau = Fr$$

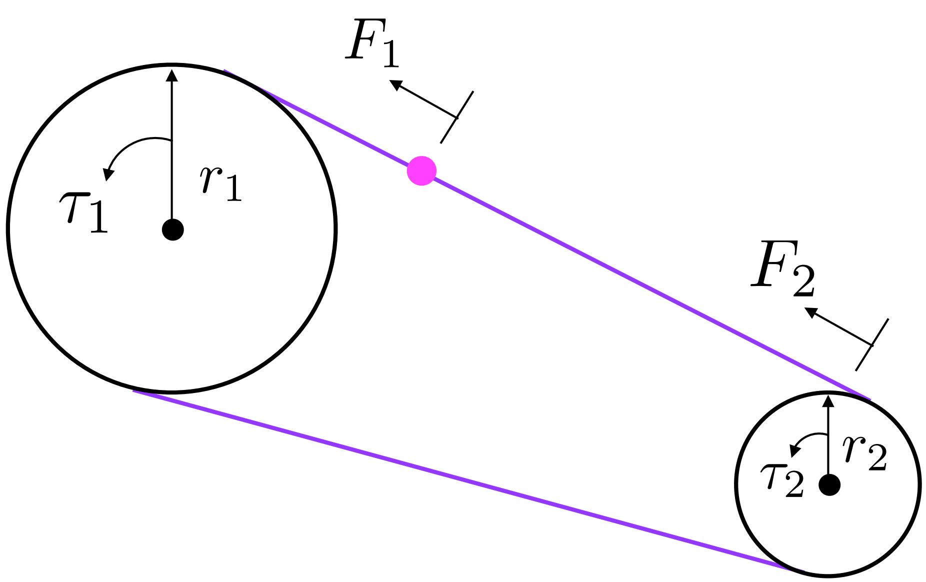
torque force radius



Q: Why are transmissions (like the cable drive in Hapkit) typically designed so that the force will be perpendicular to r?

Force-Torque Relationships

Belt-on-pulleys example



$$\tau_1 = F_1 r_1$$

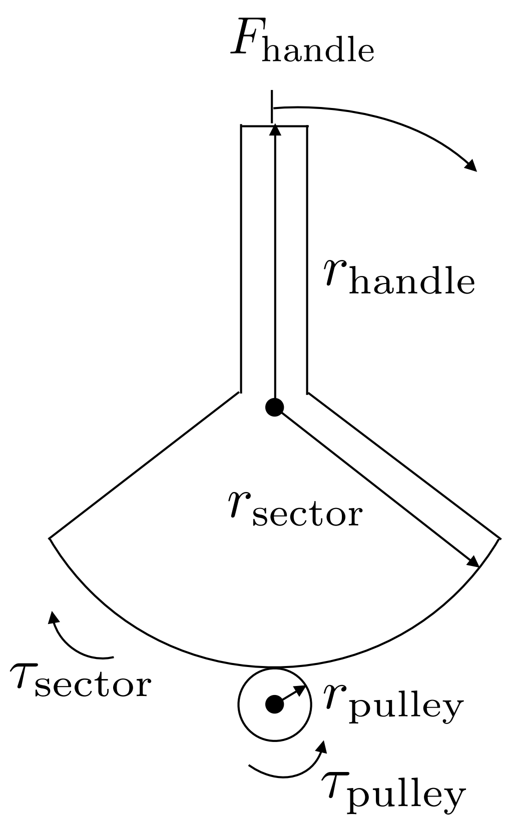
$$F_1 = \frac{\tau_1}{r_1}$$

$$F_1 = F_2$$

$$\tau_2 = F_2 r_2$$

$$\tau_2 = \frac{r_2}{r_1}\tau_1$$

Hapkit Kinematics: Forces/Torques



relationship between force and torque: $\tau = Fr$

$$\frac{\tau_{\text{pulley}}}{r_{\text{pulley}}} = \frac{\tau_{\text{sector}}}{r_{\text{sector}}}$$

$$F_{\text{handle}} = \frac{\tau_{\text{sector}}}{r_{\text{handle}}}$$

$$F_{\text{handle}} = \frac{r_{\text{sector}}}{r_{\text{handle}} r_{\text{pulley}}} \tau_{\text{pulley}}$$

Q: Say the motor can generate a torque $\tau_{\text{pulley}} = \tau_{\text{max}}$. What radius would you change to increase F_{handle}?

Solidworks

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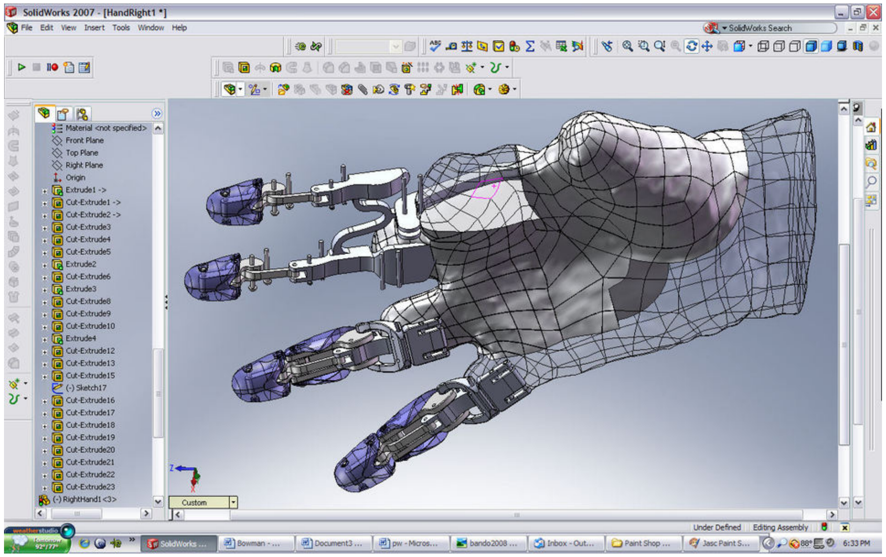

Your TO DO list

- If you have not done so already, complete Product Realization Lab safety training by Thursday (http://webshop.stanford.edu).

- This Thursday, meet at 1:30 pm SHARP outside Room 36 in the Huang Center (this is the PRL Room 36).
  WEAR CLOSED-FOOT SHOES!

- Personalize and 3D print your Hapkit handle.

- On Tuesday, bring your laptop and power cord to class, along with your printed Hapkit handle.