Engaging Young Engineers

Mark Somerville, Professor & Special Advisor to the Provost, Olin College

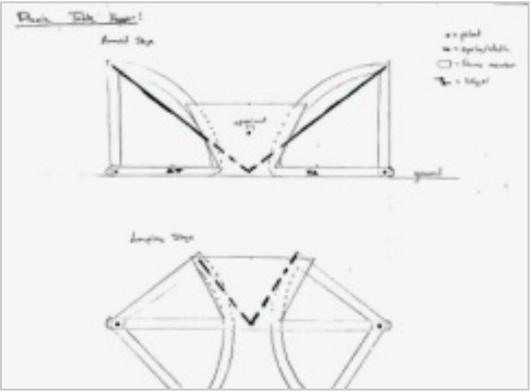
Olin College?

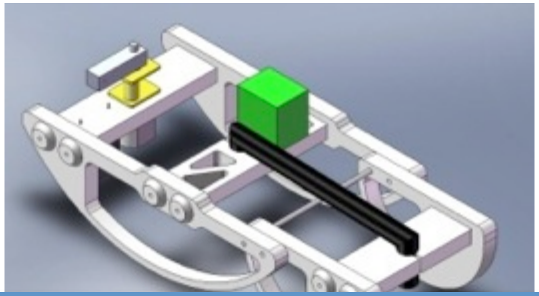
Opened for classes in 2002 in Needham, Massachusetts

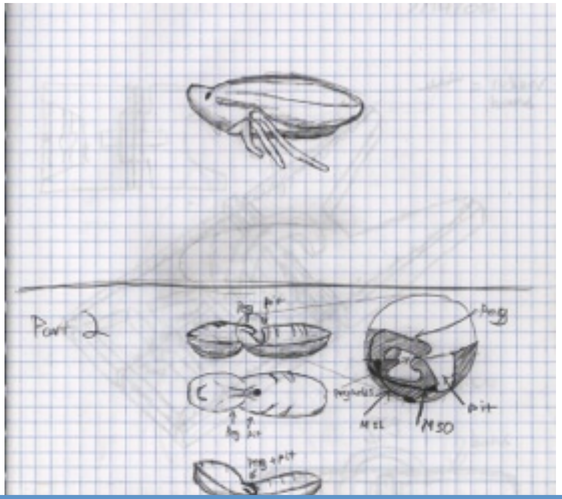
350 students, 40 faculty

Dual mission: developing students as innovators and transforming engineering education more broadly

KEY CURRICULAR FEATURES

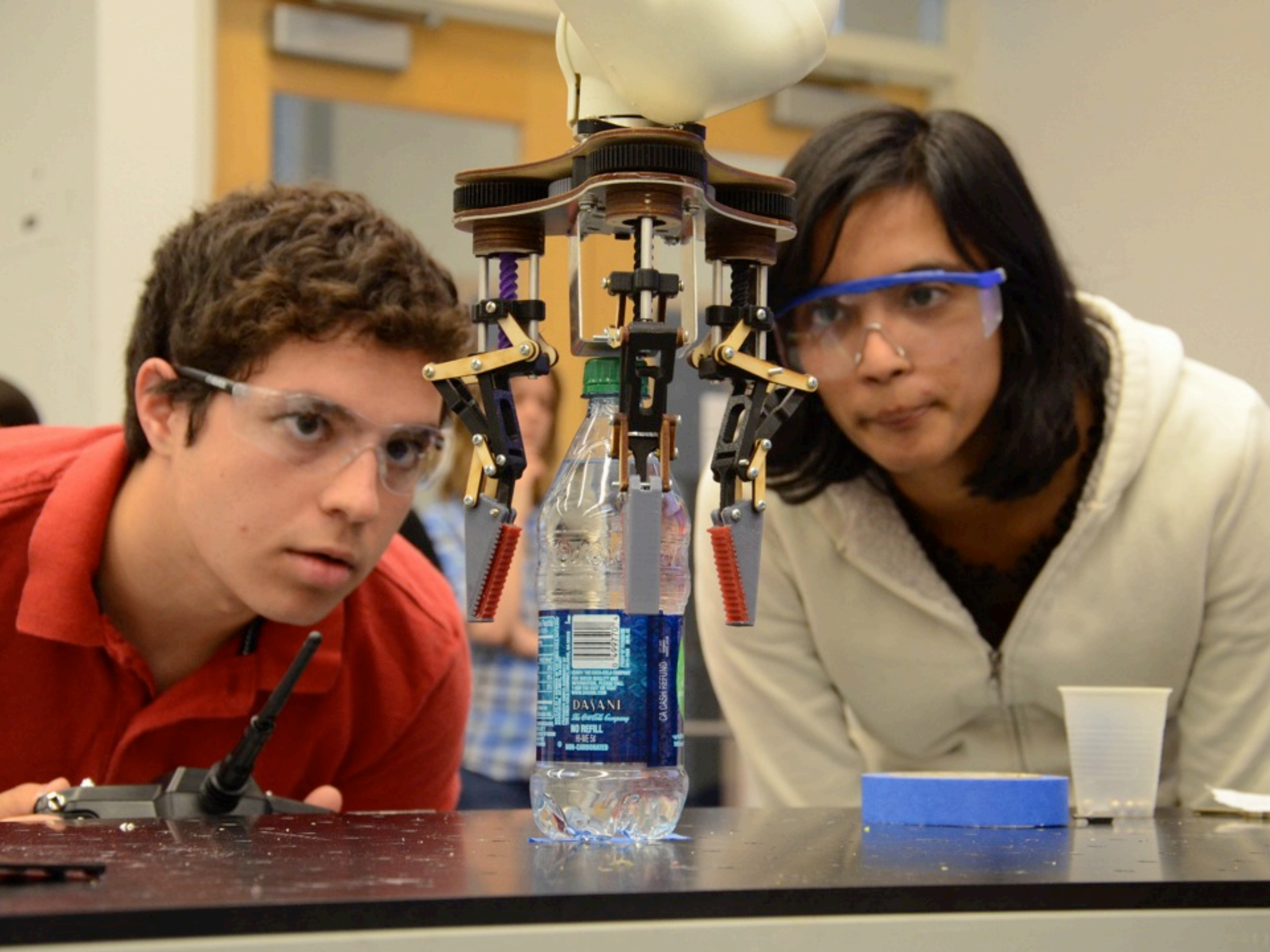






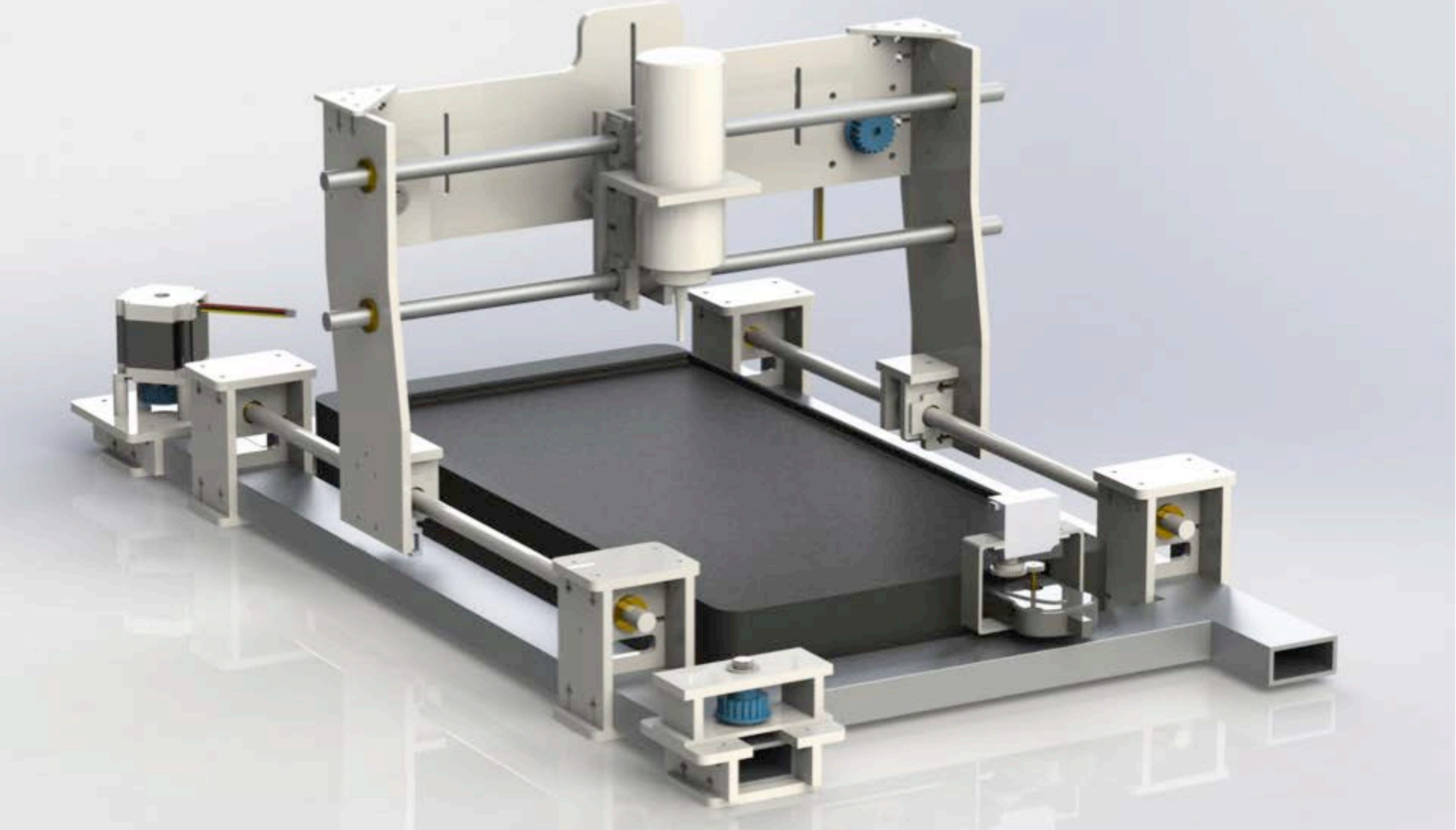
Hands-on design experiences throughout – with a heavy process emphasis


hello!


DASANI
NO REFILL


HBS

Failing, and reflecting



“We had been so weight conscious in the design of this model that we overlooked its structural rigidity. As the model relied on our Teflon bushings being completely parallel to each other, the smallest amount of flex caused complete friction lock in the major axis.”

communicating and defending their work

The Lorentz Force Law is given in Equation 1.

$$F = Q[\vec{E} + (\vec{v} \times \vec{B})] \quad (1)$$

where $\vec{E}$ is the Electric Field, $\vec{B}$ is the Magnetic Field, Q is the particle's charge, and $\vec{v}$ is the particle's velocity.

Using Newton's Second Law and Equation 1, we can derive the equation of motion for a particle traveling through the trap, shown in Equation 2.

$$\ddot{r} = \frac{Q}{m}[\vec{E} + (\vec{v} \times \vec{B})] \quad (2)$$

where $\ddot{r}$ is the particle's acceleration and m is the mass.

A proton confined in a conventional Penning trap has cyclotron motion with three modes of oscillation: the magnetron motion, the modified-cyclotron motion, and the axial motion. The three eigenfrequencies, which are essential in our investigation, stem from these three modes of oscillation.

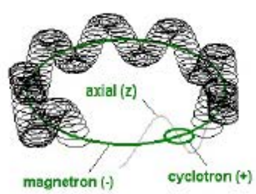


Fig. 2. This figure labels the three oscillation modes of cyclotron motion [5].

In order to discuss the three essential frequencies, we must first define the three oscillations and understand their causes.

First, the modified-cyclotron motion– labeled as "cyclotron (+)" in Figure 2– is dependent solely on the magnetic field of the system. The magnetic field is directed in the positive z-direction and applies an inward force on the proton. The Lorentz Force Law states that the applied force is orthogonal to both the particle's velocity and the direction of the magnetic field. This relationship causes the particle to have modified-cyclotron motion, which is a function of the micro x-y position over time. The frequency of this motion is the modified-cyclotron frequency.

Second, the gradient of the electric field in the z-direction is responsible for the axial motion labeled "axial (z)" in Figure 2. The opposing z-components of each point charge's electric field keeps the proton oscillating about the x-y plane, also referred to as the trap axis. At points above the trap axis, the proton is repelled downward in the negative z-direction; whereas, at points below the trap axis, the proton is directed upwards in the positive z-direction. The frequency of this motion is the axial frequency measured as a function of the z-position over time.

Lastly, the magnetron motion which is labeled in Figure 2 as "magnetron (-)", is dependent on both the electric field and magnetic field of the trap. The positively-charged proton is attracted to the negatively-charged loop; therefore, the electric field exerts an outward force on the proton. On the other hand, the magnetic field exerts an inward force on the proton. This push-and-pull behavior results in the proton's larger circular trajectory. Since the magnetron motion does not contain an axial component, it is a function of the particle's macro x-y position over time. The associated frequency is the magnetron frequency of motion.

These motions will be utilized in the next section to determine the three eigenfrequencies of motion. They will then be re-evaluated after the addition of the second proton in order to investigate the particle-to-particle interaction.

III. Results

In the previous section, we presented a model for a single trapped proton and discussed the three modes of oscillation associated with its cyclotron motion. Now we present the simulated motion and discuss the changes in cyclotron motion after we introduce another proton to the Penning Trap.

As stated earlier, the axial motion is a function of the proton's z-position over time, represented by the tan line in Figure 3. By inverting the period of this graph, we can determine the axial frequency of motion. This same approach is also applied to identify the magnetron and modified-cyclotron frequencies, which are both functions of the proton's x-y position over time. The graphs of the x-position and the y-position over time are identical excluding a phase shift; we arbitrarily choose to analyze the x-position graph. This graph is represented by the tan line in Figure 4.

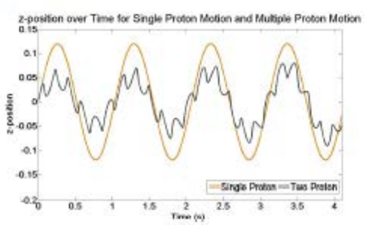


Fig. 3. This graph superimposes the z-position over time graphs of the first proton's motion before and after the addition of the second proton. The second proton was placed at the origin and given an initial velocity in the y-z direction.

The magnetron frequency, axial frequency, and modified-cyclotron frequency for the single trapped proton are plotted as tan triangles in Figure 5. The amplitudes of motion for the single trapped proton are represented by tan triangles in Figure 6.

We will use these results as a basis for comparison and now extend our model to include a second proton. We hold constant the initial position and initial velocity of the first

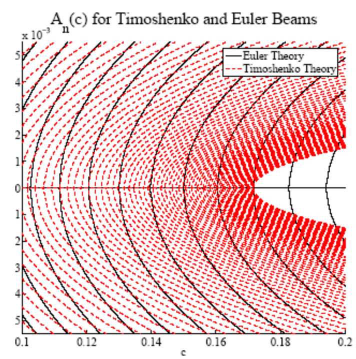


Figure 2: $A_n(c)$ for the first 100 modes, according to each theory in a 1 in^2 x 48 inch long square Al6061-T6 beam. Note the accumulation in bifurcations as c_n^t approaches $c_\infty^t = .1900$.

3.4 Stability of the Static Solutions to Timoshenko Beam Theory

As in the analysis of Euler-Bernoulli beam theory, to test the stability of the static solutions for the Timoshenko beam we again consider the linearization of the dynamic Timoshenko beam theory about the n^{th} buckled state, using the same definitions, (17) and (18), in (2) to obtain

$$\begin{aligned} v_{xxxx} + \lambda_0 v_{xx} + \Lambda w_{oxx} + v_{tt} - \alpha(1+\beta)v_{xxtt} + \beta\alpha^2 v_{tt} \\ = -\beta\alpha^2(\lambda_0 v_{xx} + \Lambda w_{xx})_{tt} + \beta\alpha\lambda_0 v_{xxxx} + \beta\alpha\Lambda w_{xxxx} \end{aligned} \quad (40)$$

$$v = v_{xx} = 0 \quad \text{for } x = 0, 1$$

$$\frac{\partial^i v(x,0)}{\partial t^i} = g_i(x) \quad \text{with } i = 0,1,2,3,4$$

Equations (20), (22), and (24) still hold. These are substituted into (40), which is multiplied by $\sin(p\pi x)$, and integrated from 0 to 1 with respect to x. The resulting characteristic equation is now biquadratic due to the v_{tttt} term

$$\sum_{p=1}^{\infty} \frac{\partial^4 S_p(t)}{\partial t^4} + r_p \frac{\partial^2 S_p(t)}{\partial t^2} + s_p S_p(t) = 0 \quad (41)$$

Working with real people


16


कृपया गंदगी
ना फैलायें

Outcomes

Highly rated nationally

Gordon Prize for Educational Innovation

Applicants in top 1% nationally

Graduates going to top companies and PhD programs

Multiple successful startups

Visits by 150+ of institutions yearly

BUT HOW DO YOU SCALE?

THINK ABOUT STUDENT ENGAGEMENT

Material that follows shared courtesy of Jon Stolk and Rob Martello

“At our institution, we have a lot of **unmotivated** students.”

There’s no such thing as “**motivated**” and “**unmotivated**” people.

People are motivated differently in **different situations**.

Amotivation

External Regulation

Identified Regulation

Intrinsic Motivation

Amotivation	External Regulation	Identified Regulation	Intrinsic Motivation


going to fail this exam.

Amotivation	External Regulation	Identified Regulation	Intrinsic Motivation

Amotivation

External Regulation

Identified Regulation

Intrinsic Motivation

This activity wasn't always fun, but it imparted some valuable skills.

This project is going to help me get an internship.

Amotivation	External Regulation	Identified Regulation	Intrinsic Motivation


finish my project.

The **type** of motivation matters for learning.

+INTRINSIC motivation

- + self-efficacy
- + task value
- + interest
- + enjoyment
- + persistence
- + retention
- + self-regulation
- + critical thinking
- + metacognition
- + academic performance

e.g., Deci et al. 1999, Deci & Ryan 2000, Vansteenkiste et al. 2006, Noels et al 1999, Wolters 1998, Black & Deci 2000

+EXTRINSIC motivation

+ anxiety
+ feelings of pressure, coercion, guilt
+ reward-focused goals
+ reduced deep understanding
+ lower achievement
+ low self-esteem

e.g., Deci et al. 1999, Deci & Ryan 2000, Vansteenkiste et al. 2006, Noels et al 1999, Wolters 1998, Black & Deci 2000

A **shift** to intrinsic motivation is possible ...
given the right conditions.

+ **autonomy**
+ **relatedness**
+ **competence**

+ competence

I am confident that I can succeed.

I feel like I'm getting better at this.

I'm getting positive feedback.


mastery experiences

+ relatedness

I am connected to other people.

I feel what I do matters.

I belong to a group or community.

My work has positive impacts.

community connections

+ autonomy

I have some freedom.

I'm making meaningful choices.

I'm in control of my learning.

find ways to give students **choice & control**

"Making universities and engineering schools exciting, creative, adventurous, rigorous, demanding, and **empowering milieus** is more important than specifying curricular details."

-Dr. Charles Vest