Chemical & Physical Sciences
UNIVERSITY OF TORONTO
MISSISSAUGA

Promoting Student Success in First-Year Physics at UTM

An **Interdisciplinary** Initiative for Student Success

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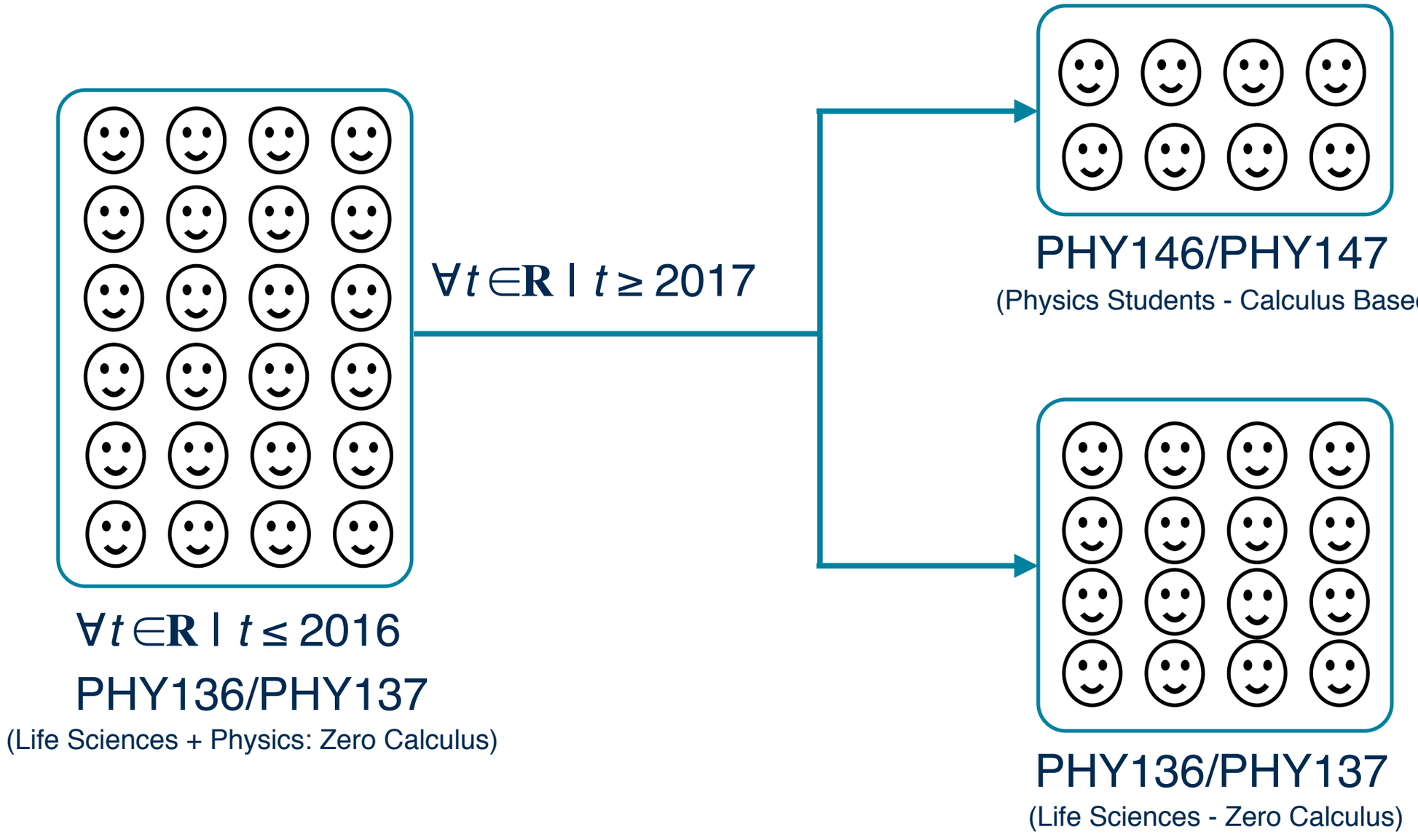
Our Story Begins in September 2017



UTM Physics++

A Day in the Life of a Physics Major

Early September

First-Year Physics

A particle's position on the x-axis is given by $x(t) = (t^2 - 4t + 2)$ m where t is in seconds. Determine the particle's velocity at $t = 1.0$ s. At what time is the particle closest to the origin?

Mathematical Concepts Needed: Derivatives, Optimization
Time of First Exposure in Math Class: Basic intro in Grade 12 Calculus & Vectors, robust intro **October** of First Year

First-Year Calculus

Solve the following inequality: sin(x) > cos(x)

Mathematical Concepts Needed: Inequalities, Restrictions, Domain/Range
Time of First Exposure in Math Class: Grade 12 Advanced Functions

The Curriculum Gap is Small, but Non-Zero

A Day in the Life of a Physics Major

Late September

First-Year Physics

A particle's acceleration is described by the function $a_x = kt^2$ m/s², where *k* is a constant and *t* is in s. The particle's position at t_0 = 0 s is x_o = -9.0 m. At t_1 = 3.0 s, the particle is at x_1 = 9.0 m. Determine the value of the constant *k*.

Mathematical Concepts Needed: Integration, Initial Conditions
Time of First Exposure in Math Class: **January** of First Year

First-Year Calculus

Compute the value of $\lim_{t \to 0} \frac{\sqrt{t^2+9}-3}{t^2}$

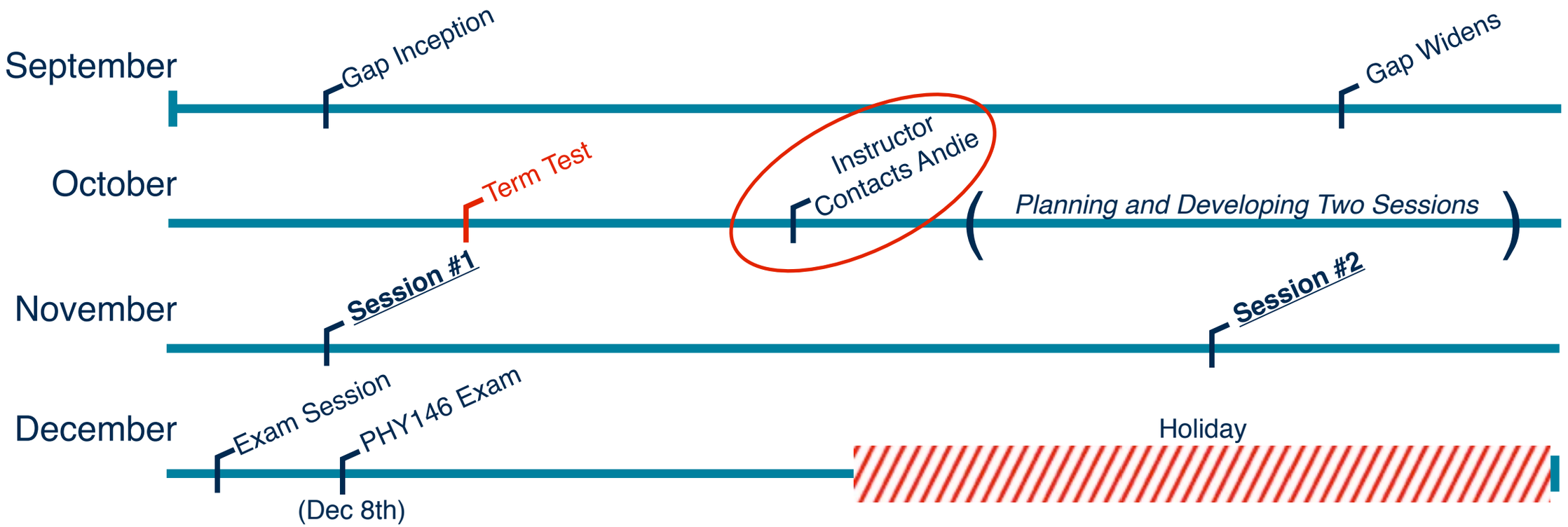
Mathematical Concepts Needed: Introductory Limits, Conjugates
Time of First Exposure in Math Class: Grade 12 MCV4U0 (Calculus and Vectors)

The Curriculum Gap Grows Quickly

"Sir, what does the big "S" mean?" $\int$

Genesis of Our Initiative

Maiden Timeline PHY146 Course (2017)



Ad-Hoc Sessions were Created 2 Months into Term

Structure of Each Session

Narrow Focus - 1 or 2 Concepts

1 hr

10 mins - U of T time (buffer time to get to class)

20 mins - Introduction of new math concepts - lecture style

10 mins - Worked examples of increasing complexity

20 mins - Activity Worksheet - Group Work

“Just In Time” Approach

Positive Feedback Lead to Growth

- ~50% of the class attended these sessions regularly
- “Survey said”: sessions were instrumental in their understanding
- Proposed **continuation** of sessions into **second semester**
- **Official pilot program** was launched through the UTM **RGASC**
- Interdisciplinary Initiative was officially formed!

Expansion of Initiative

PHY147 Course (Jan 2018)

(Following Semester)

Monday	Tuesday	Wednesday	Thursday	Friday

x8

Math Session

(Same Structure as Before)

"Here are the tools"

Physics Session

"Here's how to use them"

The Structure of the Physics Sessions

Narrow Focus - 1 or 2 Concepts

1 hr

10 mins - U of T time

10 mins - Big Picture Review of Math Session

20 mins - Motivating Examples: Problem-Based Learning
(Problems that Depict Use of Math Within Physics Problems)

20 mins - Activity Worksheet - Group Work

Example

Variable Acceleration

Calculus-Based

A particle's acceleration is described by the function $a_x = kt^2$ m/s², where *k* is a constant and *t* is in s. The particle's position at t_0 = 0 s is x_o = -9.0 m. At t_1 = 3.0 s, the particle is at x_1 = 9.0 m. Determine the value of the constant *k*.

(From Earlier Slide)

Constant Acceleration

Algebraic-Based

A particle's acceleration is *a = 10* m/s². If the particle starts at *x = -4* m with an initial speed of v_i = -3 m/s, when will the object be at the origin?

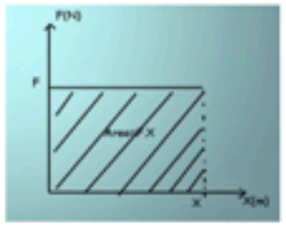
$$\Delta x = v_i t + \frac{1}{2} a t^2$$

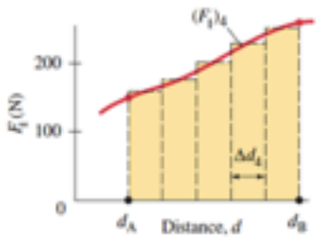
Illustrates that Real World Problems Require Calculus

PHY146 Physics Help Session
Work done

$$dW = F(x)dx$$

$$W = \int_a^b F(x)dx$$





$$W = \sum_{i=1}^{n} F(x_i)\Delta x$$

$$\downarrow$$

$$W = \int_{x_1}^{x_2} F(x)dx$$

Examples of forces that are NOT constant:

$F_g = \frac{-Gm_1m_2}{x^2}$ (Newton's law of gravity)

$F_s = -kx$ (Spring Force)

$F_{\text{elec}} = \frac{kq_1q_2}{x^2}$ (Coulombic Force)

Exercise 1:

Determine the work done on an object subject to each of the above forces, separately, starting from a position of zero force.

Exercise 2:

The force on a particle is directed along the x axis and given by $F = F_0(x/x_0 - 1)$, where F_0 and x_0 are constants. Find the work done by the force in moving the particle from $x = 0$ to $x = 2x_0$ by

a) plotting F(x) and measuring the work from the graph and

b) integrating F(x).

Exercise 3: A single unknown force acts on a 3.0 kg particle-like object what results in a position that is given by $x = 3t - 4t^2 + 1t^3$, with x measured in meters and t in seconds. Find the word done by this unknown force from t = 0 to t = 4s.

Solution: We don't know the force, so we can't use $W = \int F(x)dx$. We then remember the "Work-Energy Theorem": $W = \Delta E_k = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$.

So we need the velocity.

$v(t) = x'(t) = 3 - 8t + 3t^2$

$W = \frac{1}{2}m(v(4)^2 - v(0)^2)$

$W = \frac{1}{2}(3)(19^2 - 3^2)$

W = 528 J

Difference from Tutorial and Lecture

Lectures

- Delivers new content
- Provide Motivation for Content (hopefully)
- Demonstrations (again...hopefully)

Tutorials

- Review, Summarize, Assess

Help Sessions

- Create a link between subjects (math and physics)
- Accelerate Delivery of Key Mathematical Tools
- Unsure Uniform Prior Knowledge

Non-Linear Growth (a good thing in this case…)

September 2018

- Sessions **Continued** for **PHY146/7** in the 2018-2019 Academic Term
- Sessions for **Second-year** Physics Courses (Sept. 2018) were **Added**
  - 6 Sessions were Planned for Electromagnetism (**PHY241**)
  - 5 Sessions were Planned for Vibrations and Waves (**PHY245**)

Support Sessions for all 1st- and 2nd-year Courses

Main Topics Covered (E&M PHY241)

1. Del Operator, Divergence, Gradient, and Curl
2. Line, Surface, and Volume Integrals
3. Stokes Theorem
4. Divergence Theorem/ Gauss's Law
5. Laplace Equation

Main Topics Covered (Waves PHY245)

1. Complex Numbers
2. Introduction to Second-Order O.D.E.'s
3. Solving Second-Order O.D.E. (constant coefficients)
4. Particular Solutions
5. Fourier Series

UTM is Student First

1. We Recognized an Issue and Tried to Correct it

2. Extra Support Students for 50% of their Undergrad (these sessions)

3. Expand Sessions into other disciplines (e.g. Chemistry, CS, Stats.)

4. UTM has an Entire Department Dedicated to Student Support

   (language, writing, numeracy, etc.)

5. Robert Gillespie Academic Skills Center (RGASC) - (UTM only!!!)

We Would Like to Thank the **RGASC** for their Funding and Support of this Initiative!

Thank You!

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