ME 274 Lecture 1

Eugenio “Henny” Frias-Miranda

1/11/26

ME 274 Logistics

- Henny will send an email with syllabus by the end of the day.
  - My OH location may change; I will keep you guys updated.
- Tutorial room opens on Friday (will let you guys know of logistics ASAP)
- Brightspace
  - Not used significantly, primarily for announcements and file sharing
- Gradescope
  - Used For submitting Quiz’s, HWs, and Exams
- 10-12 quizzes through the semester. **If you email me before class, I will excuse you from the quiz.**
- Straight scale course
- Grade breakdown 25:75 (HW/Quiz’s:Exams)
- Bonus points (eg. Writing on the course blog)
- No late HW, we drop the lowest 3 HWs
- *Go over syllabus

Course Website 101

www.purdue.edu/freeform/me274/

- Log in to use blog functionality
- “Daily Schedule Section”
    - The material we will cover each day in lecture.
      Recommended you take a look at if you have to miss lecture.

Dynamics A Lecturebook 101

- Recommend you buy it so you can write during the lecture
- 6 Chapters
- Section Structure:
    - Theory
    - Questions
- Conceptual questions at the end of each chapter(!)
    - *Course website has hints for all of these

ME274 Outline:

I) Kinematics – *What is the motion?*

1) Point Kinematics

(a) Cartesian — **Lecture 1**

(b) Path — **Lecture 2**

(c) Polar / Cylindrical — **Lecture 3**

2) Planar Kinematics

(a) Joint Descriptions — **Lecture 4**

(b) Relative and Constrained Motion — **Lecture 5**

(c) Rigid Bodies — **Lectures 6–8**

(d) Instant Centers — **Lecture 9**

3) Moving Reference Frame Kinematics

(a) 2D — **Lectures 11–12**

(b) 3D — **Lectures 12–15**

II) Kinetics – *Why is the motion happening?*

1) Particle Kinetics

(a) Newton's 2nd Law — **Lectures 16–18**

(b) Work / Energy — **Lectures 19–20**

(c) Linear Impulse / Momentum — **Lectures 21–22**

(d) Central Impact — **Lecture 23**

(e) Angular Impulse / Momentum — **Lectures 24–25**

2) Planar Kinetics of Rigid Bodies

(a) Newton / Euler Equations — **Lectures 27–29**

(b) Work / Energy — **Lectures 29, 31**

(c) Impulse / Momentum — **Lectures 32–33**

III) Vibrations – *What happens when motion repeats/oscillates?*

(a) Equations of Motion — **Lecture 35**

(b) Free, Undamped Response — **Lecture 36**

(c) Free, Damped Response — **Lectures 37–38**

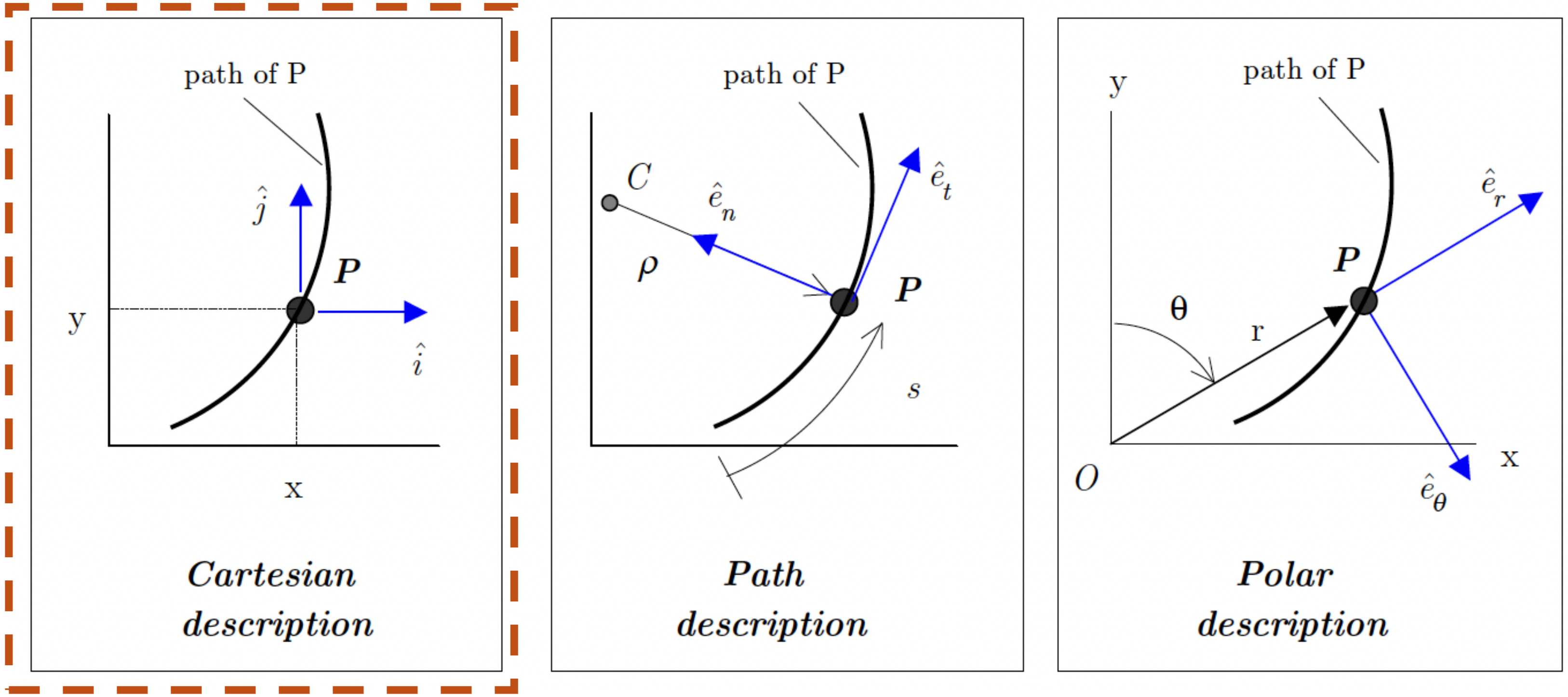
(d) Harmonic Excitation — **Lectures 39–41**

Point Kinematics – Section 1.A

As always, the velocity and acceleration of point **P** are given by the first- and second-time derivatives, respectively, of the position vector $\vec{r}$ for **P**.

$$\vec{v} = \frac{d\vec{r}}{dt} \qquad \vec{a} = \frac{d^2\vec{r}}{dt^2}$$ [pg. 30]

Today's Lecture:



[pg. 30]

The kinematics of velocity and acceleration may be described in Cartesian, path, or polar coordinates (figure above).

Point Kinematics – Cartesian Description

- Today's Fundamental equation:

$$\vec{v} = \frac{d\vec{r}}{dt} = \dot{x}\hat{i} + \dot{y}\hat{j}$$

[pg. 31]

$$\vec{a} = \frac{d^2\vec{r}}{dt^2} = \ddot{x}\hat{i} + \ddot{y}\hat{j}$$

- Thing to keep in mind: Chain Rule

$$\vec{v} = \frac{d\vec{r}}{dt} = \frac{d\vec{r}}{ds}\frac{ds}{dt} = v\frac{d\vec{r}}{ds}$$

[pg. 33]

Example 1.A.2 [pg. 42]

Given: A particle P moves on a path whose Cartesian components are given by the following functions of time (where both components are given in inches and time t is given in seconds):

$$x(t) = t^3 + 10$$
$$y(t) = 2\cos 4t$$

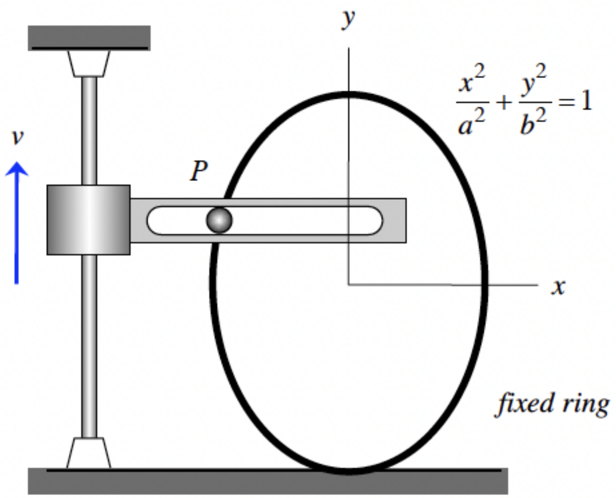
Find: Determine at the time $t = 2$ s:
(a) The velocity vector of P;
(b) The acceleration of P; and
(c) The angle between the velocity and acceleration vectors of P.

Example 1.A.1 [pg. 41]

Given: Pin P is constrained to move along a elliptical ring whose shape is given by $x^2/a^2+y^2/b^2 = 1$ (where x and y are given in mm). The pin is also constrained to move within a horizontal slot that is moving upward at a constant speed of v.

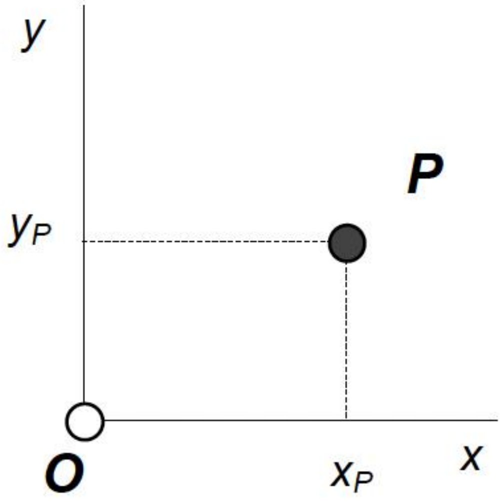
Find: Determine:
(a) The velocity of pin P at the position corresponding to $y = 6$ mm; and
(b) The acceleration of pin P at the position corresponding to $y = 6$ mm.

Use the following parameters in your analysis: $a = 5$ mm, $b = 10$ mm, $v = 30$ mm/s.



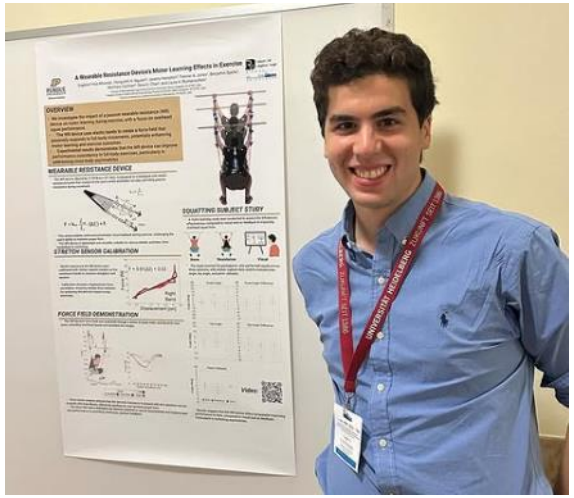
Question C1.2 [pg. 70]

Point P moves on a path described by $y_P = x_P^2/2$ with $x_P(t) = 3\sin\pi t$, where x_P and y_P have units of meters and t has units of seconds. Determine the acceleration vector of P at $t = 0$.



Eugenio "Henny" Frias-Miranda

- **School:** 4th Year PhD student at Purdue in soft and wearable robotics
- **Hobbies:** Soccer, learning about technology, going on walks
- **From:** San Juan, Puerto Rico



Soft Growing “Vine” Robots

[Hawkes et al, 2017]

“Water wiggly” toy

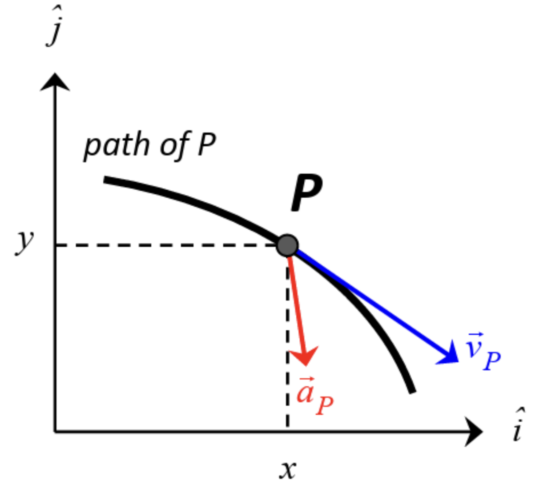
[Blumenschein et al, 2021]

[Adapted from ICRA 2025 Keynote Prof. Allison Okamura]

Summary: Particle Kinematics – Cartesian Description

1. *PROBLEM*: Motion of a point is described in Cartesian *xy*-coordinates.

2. *FUNDAMENTAL EQUATIONS*:



$$\vec{v}_P = \dot{x}\hat{i} + \dot{y}\hat{j} = velocity\ of\ P$$

$$\vec{a}_P = \ddot{x}\hat{i} + \ddot{y}\hat{j} = acceleration\ of\ P$$

with $\dot{x} = \dfrac{dx}{dt}$, etc.

3. *CHAIN RULE OF DIFFERENTIATION*: Suppose that *y* is given in terms of *x* (instead of time *t*) – how do you find $\dot{y} = dy/dt$??

The chain rule!! $\dot{y} = \dfrac{dy}{dt} = \dfrac{dy}{dx}\dfrac{dx}{dt} = \dot{x}\dfrac{dy}{dx}$ (🡐 remember this!)

4. *COMMENT*: The Cartesian description is easy to use, but not as useful as other descriptions. More later…