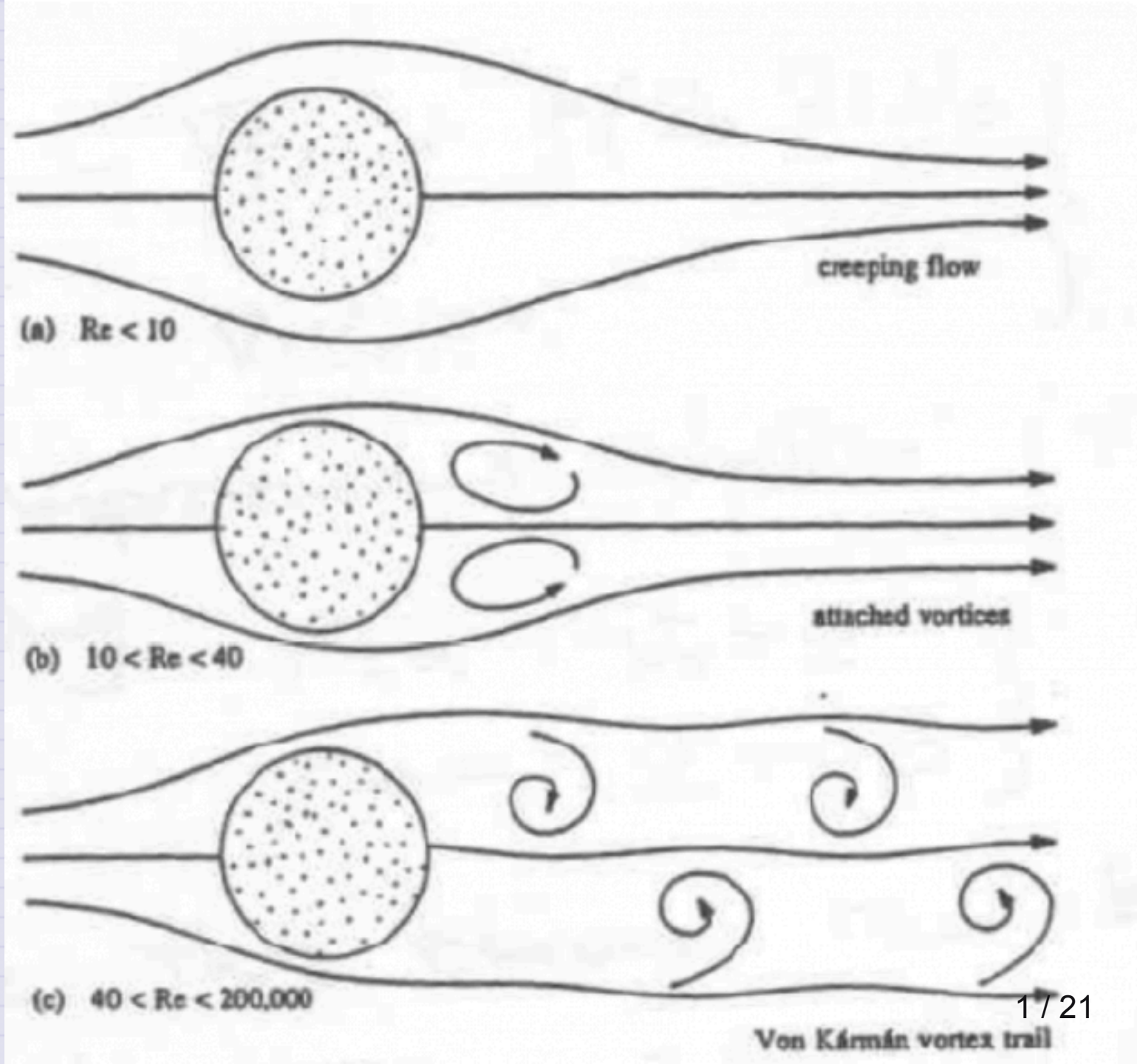
Day 06 - Making Classical Models



Plane Polar Coordinates Warm-Up

We introduced plane polar coordinates (r, ϕ). For any position vector, $\vec{R}$, we can write:

$$\vec{R} = \left|\vec{R}\right|\hat{r} = r\hat{r}$$

where r is the magnitude of $\vec{R}$, and $\hat{r}$ is the radial unit vector.

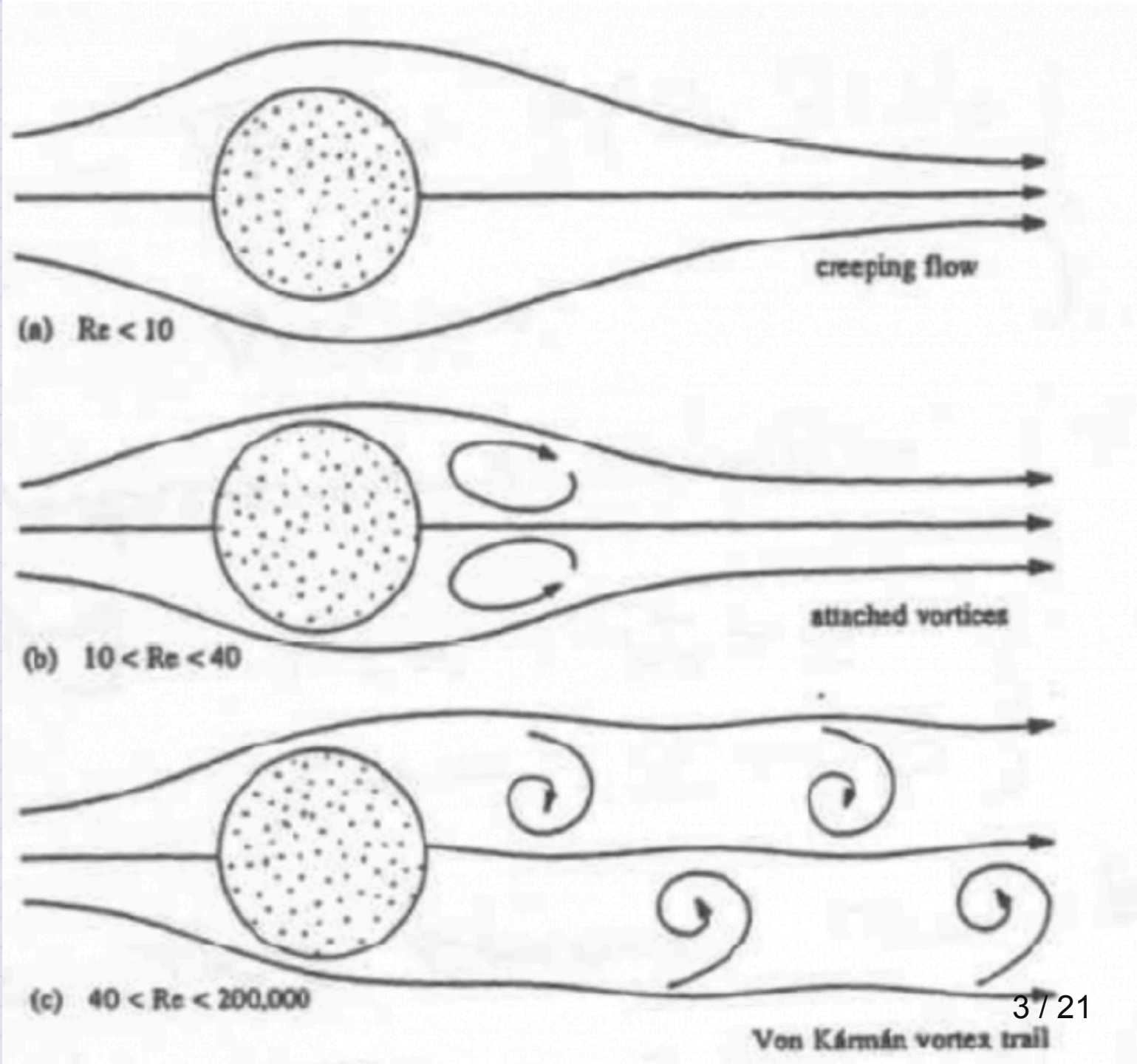
Find $\dot{\vec{R}} = \frac{d\vec{R}}{dt}$. Get as far as you can. Our answer will be in terms of $\hat{r}$ and $\hat{\phi}$.

Remember the chain rule and Cartesian unit vectors are fixed in space/time

$\hat{r} = \cos(\phi)\hat{x} + \sin(\phi)\hat{y} \qquad \hat{\phi} = -\sin(\phi)\hat{x} + \cos(\phi)\hat{y}$

$\frac{d}{d\phi}\cos\phi = -\sin\phi \qquad \frac{d}{d\phi}\sin\phi = \cos\phi$

Day 06 - Making Classical Models



Announcements

- Homework 2 is due Friday
- Video recordings have continued to fail.
  - Zoom password: phy321
- Updated office hours (Danny-DC; Elisha-EA):
  - Monday 4-5pm (DC)
  - Tuesday 5-6pm (EA)
  - Wednesday 4-5pm (DC)
  - Thursday 5-6pm (EA)
  - Friday 10-12pm (DC then EA); 3-4pm (DC)

Seminars this week

MONDAY, January 27, 2025

- Condensed Matter Seminar 4:10 pm,1400 BPS, Luca Delacretaz, University of Chicago, *Precision tests of thermalization and Planckian bound from hydrodynamic EFT*
- CAPS Connect – Abigail (Abby) Weller BPS 1312C - Starts back up today
  - 30 minute Walk-ins are available or to schedule a meeting: https://caps.msu.edu/services/CAPSConnect.html

Seminars this week

WEDNESDAY, January 29, 2025

- Astronomy Seminar, 1:30 pm, 1400 BPS, Michiel Lambrechts, Univ. of Copenhagen, *Planet formation*
- FRIB Nuclear Science Seminar, 3:30pm., FRIB 1300 Auditorium, Brenden Longfellow of Lawrence Livermore National Laboratory, *From Tensor Current Limits to Solar Neutrinos: 8Li and 8B Studies with the Beta-decay Paul Trap*

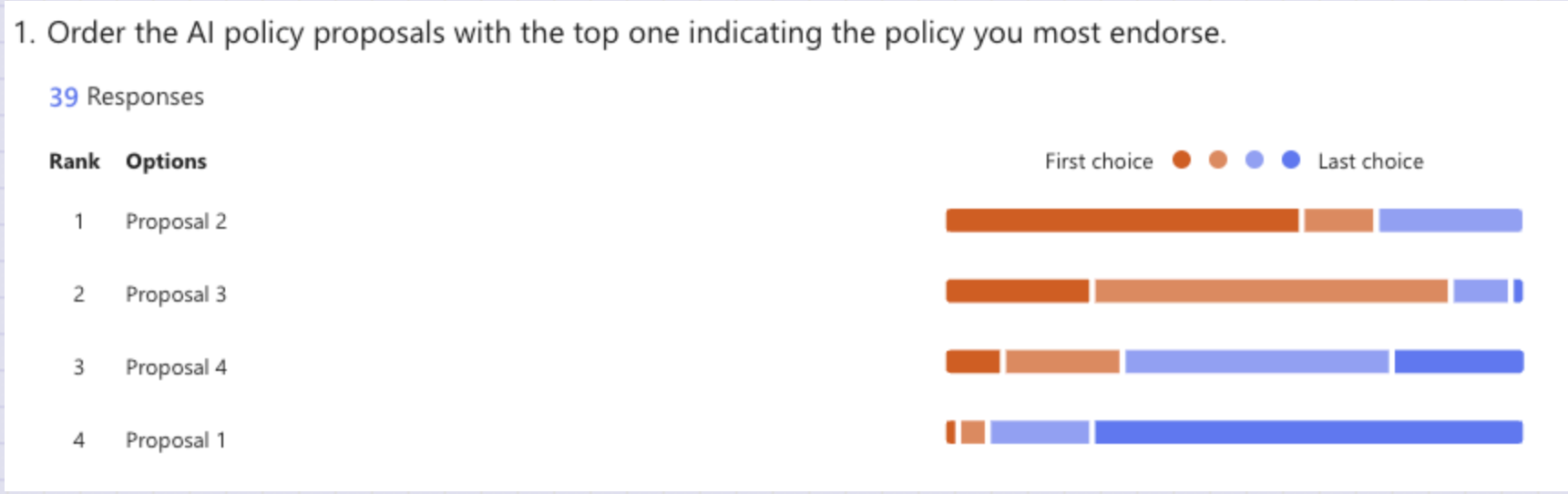
AI Policy Proposals

- **Proposal 1:** We adopt a policy that does not allow AI use at all.
- **Proposal 2:** We adopt a policy that allows AI use for brainstorming, help, and editing.
- **Proposal 3:** We adopt a policy that allows AI for use in nearly any way.
- **Proposal 4:** We adopt a policy that allows AI for use in any way with no documentation required.

Updated AI Policy

We have elected to use Proposal 2 for the AI Policy.

- Proposal 2: 61.5% first choice; 12.8% second choice
- Proposal 1: 26.5% first choice; 61.5% second choice
- Proposal 3: 46.2% third choice; 23.1% last choice
- Proposal 4: 17.9% third choice; 74.4% last choice



AI Policy going forward

To be posted on D2L and in the syllabus

- We have adopted a policy that allows AI use for brainstorming, help, and editing.
- We will not use AI tools for direct answers or the completion of assignments.
- We expect documentation of AI use, but it can be informal. The documentation should at least contain the AI tool used, the prompts given, and the responses received.
- Policy violations are discussed with Danny; the first violation requires a redo of the assignment, and repeated violations result in a failing grade.
- We will review an amendment to this policy if 1/3 of the class prepares one.

Goals for Week 3

- Be able to answer the following questions.
  - What is Mathematical Modeling?
  - What is the process for analyzing these models?
- Be able to solve "Simple" Motion Problems with Newton's Laws.

Modeling Video

Source: https://www.youtube.com/watch?v=dkTncoPqo5Y

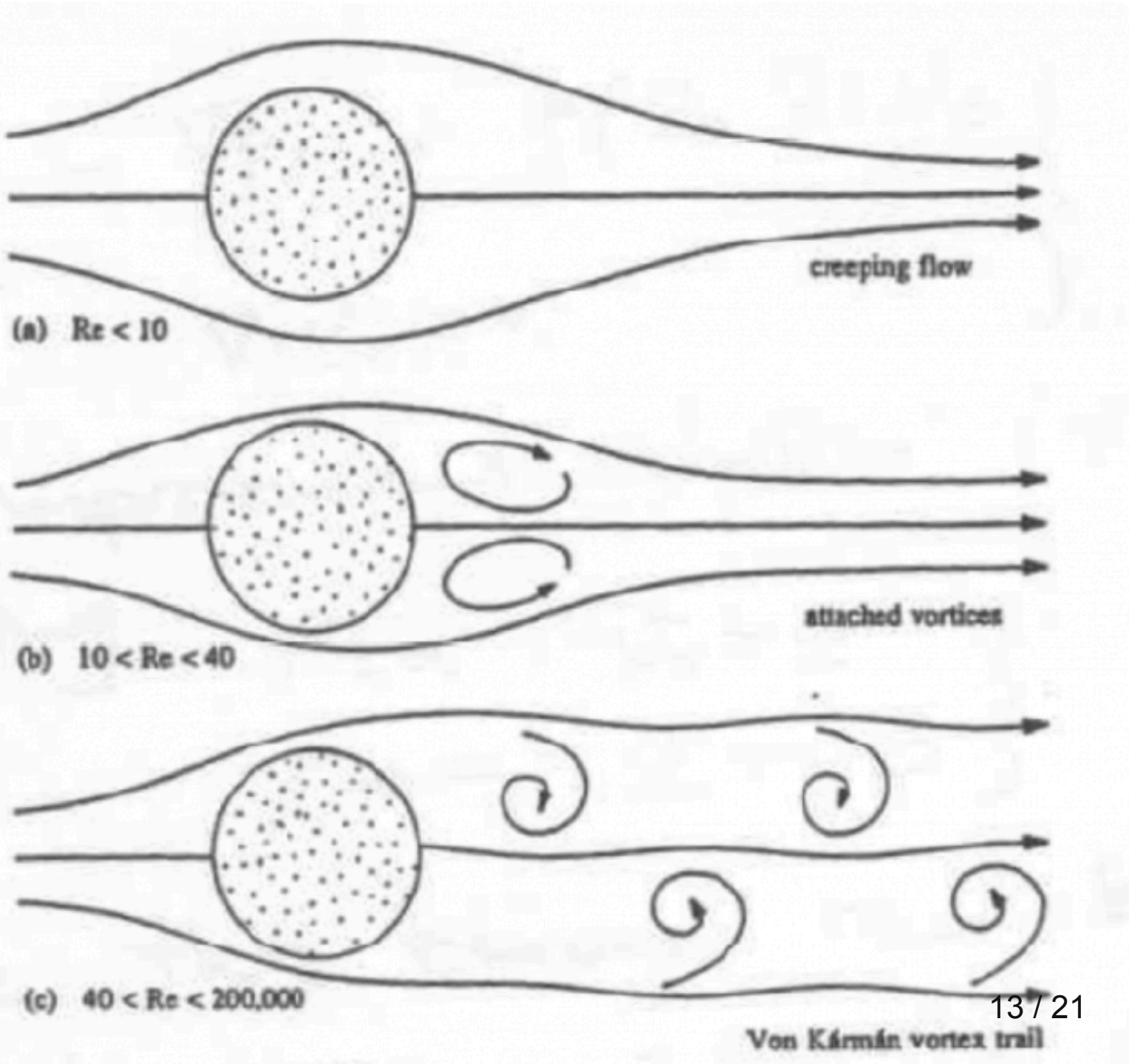
What is your experience with modeling?

Take 2-3 min to think about your prior physics classes

- What models have you used? What makes that a model?
- What made a that model good or not so good?
- What kinds of things could you do to make a better model?

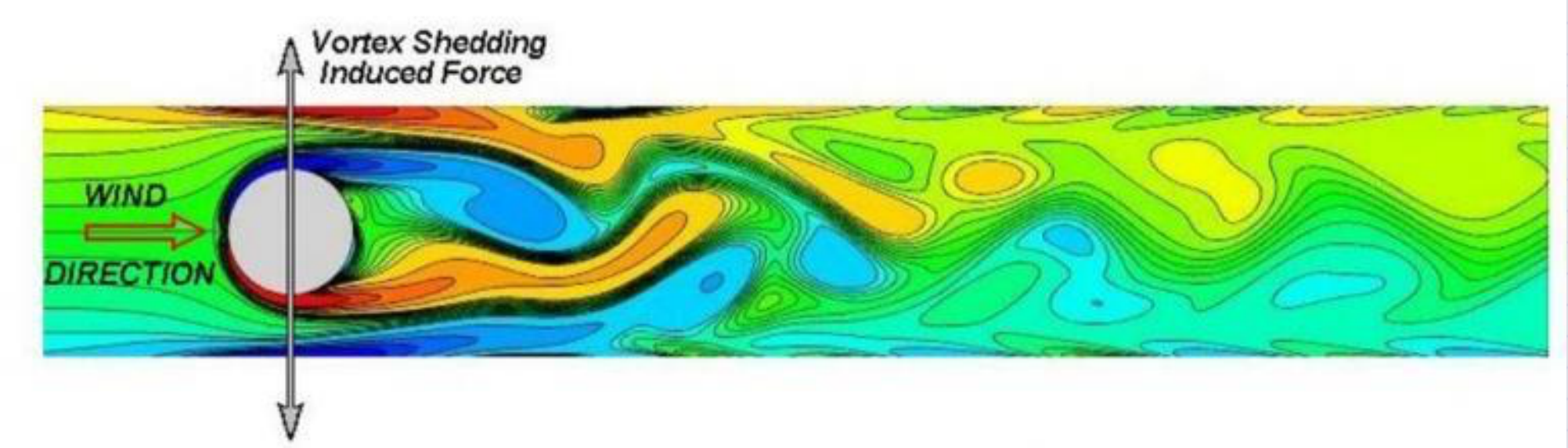
Vortex Shedding

- At higher Reynolds numbers, flow around objects becomes unstable.
- This instability can lead to the formation of vortices.
- This "shedding" of vortices can lead to vibrations and noise.



Model of vortex shedding behind a cylinder

- Controlling vortex shedding is important in many engineering applications.



Giosan, Ioan, and P. Eng. ***"Vortex shedding induced loads on free standing structures"*** *Structural Vortex Shedding Response Estimation Methodology and Finite Element Simulation 42 (2013).*

Renewables: Wind Turbines

Thorntonbank Wind Farm

North Sea off the coast of Belgium

Notice the cylindrical shape of the support structure.

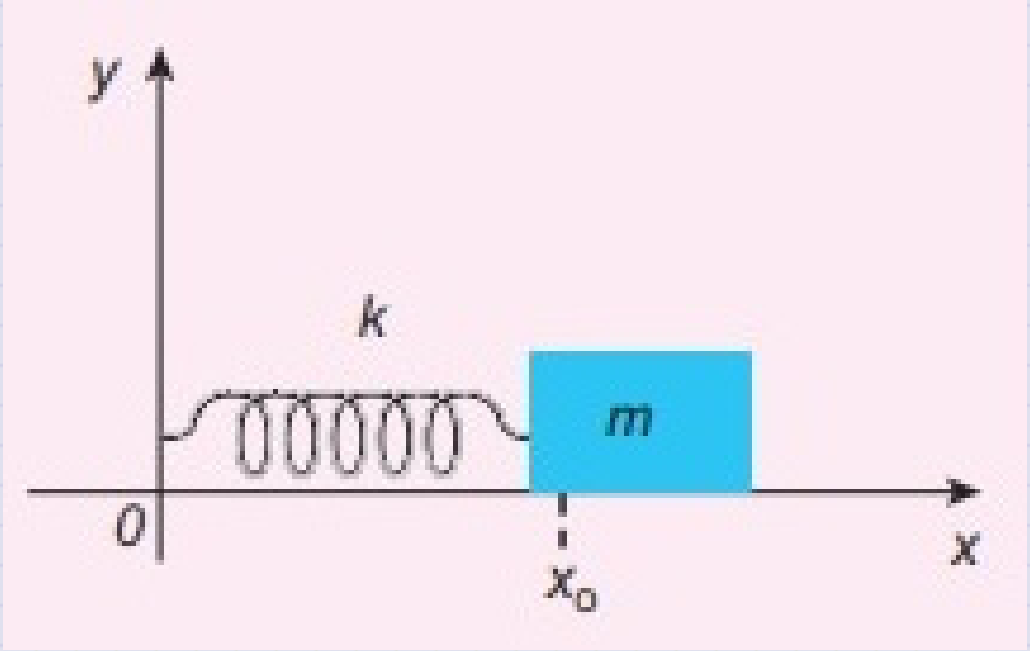
Clicker Question 6-1

The SHO is a useful model:

$m\ddot{x} = -kx$.

Assume the **restoring force is anti-symmetric** about the equilibrium position, what is the next term model?

1. $\sim x^2$
2. $\sim x^3$
3. $\sim x^4$
4. $\sim x^5$



Clicker Question 6-2

Assuming a **linear model** for Air Resistance $\sim bv$, we obtained this EOM for a falling ball:

$$\ddot{y} = -g + \frac{b}{m}\dot{y}$$

What happens when $\ddot{y} = 0$?

1. The ball stops moving ($v = 0$).
2. The ball reaches a velocity of mg/b.
3. The ball reaches a terminal velocity.
4. I'm not sure.

Clicker Question 6-3

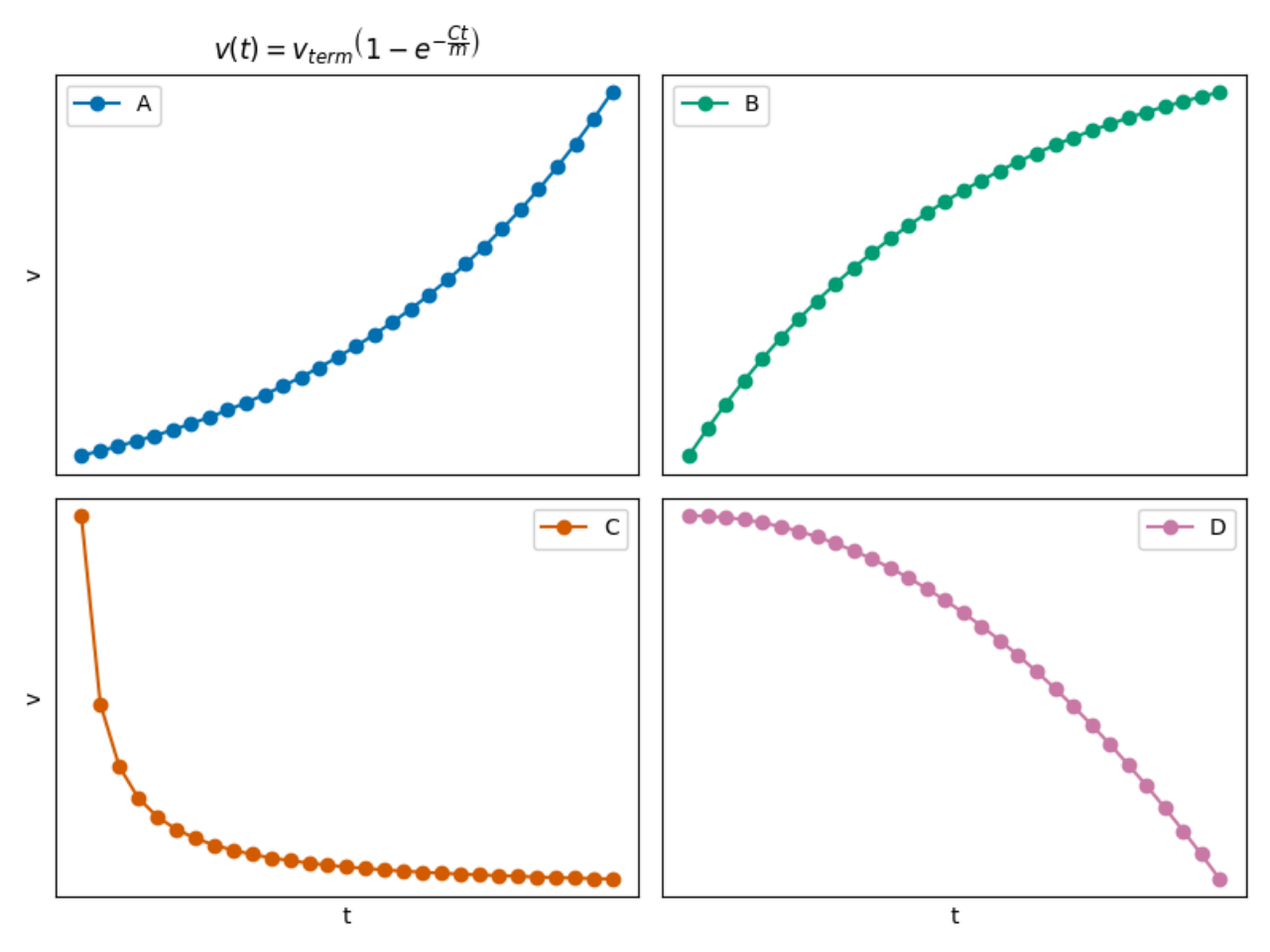
For the system of **Linear Drag in 1D**, we found a solution for the velocity as a function of time, with $v = 0$ at $t = 0$.

$$v(t) = v_{term}\left(1 - e^{-\frac{bt}{m}}\right)$$

where $v_{term} = \sqrt{\frac{mg}{b}}$.

CQ 6-3

Which sketch could be correct for the velocity of the ball?



Clicker Question 6-4

For the system of **Quadratic Drag in 1D**, we found a solution for the velocity as a function of time, with $v = 0$ at $t = 0$.

$$v(t) = v_{term} \tanh(gt/v_{term})$$

where $v_{term} = (mg/c)^{1/2}$. Do the units make sense? What are the units of $[gt/v_{term}]$?

1. Yes, the units for $[gt/v_{term}]$ are m/s;both sides have the same units.
2. No, the units for $[gt/v_{term}]$ are m/s; each side has different units.
3. Yes, the units for $[gt/v_{term}]$ are unit-less; both sides have the same units.
4. No, the units for $[gt/v_{term}]$ are unit-less; each side has the different units.

Clicker Question 6-5

For the system of **Quadratic Drag in 1D**, we found a solution for the velocity as a function of time, with $v = 0$ at $t = 0$.

$$v(t) = v_{term} \tanh(gt/v_{term})$$

where $v_{term} = \sqrt{mg/c}$. What happens when $t \to \infty$?

1. The object stops moving.
2. The object travels at a constant velocity.
3. The object travels at an increasing velocity.
4. The object travels at a decreasing velocity.
5. I'm not sure.