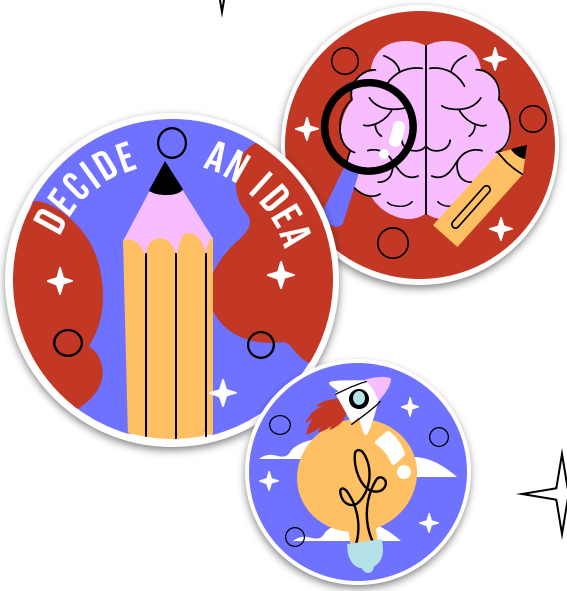
從霧裡到悟理：同儕教學 (Peer Instruction) 如何幫助學生突破物理學習盲點？



Pei-Yun Yang, Department of Physics, NTU

2025/05/10

2025物理實作平台年會

About Me

楊珮芸(Pei-Yun Yang)

- 2019 Kaufman Teaching Certificate, MIT
- Project Assistant Professor, Department of Physics, NTU since 2021

Teaching Focus:

- General Physics (a)(1)& (2) (中授/ EMI)
- General Physics (b) (EMI)

Award:

Outstanding Teaching of EMI Courses in the 2023 Academic Year

Intended Learning Outcomes

By the end of this session, participants will be able to:

- Have an understanding of the principles of Peer Instruction (PI).
- **Identify key concepts** in their courses suitable for PI activities.
- **Create conceptual questions** that encourage critical thinking and peer discussion.

What is PI?

- A teaching method developed by Eric Mazur, Department of Physics, Harvard University.

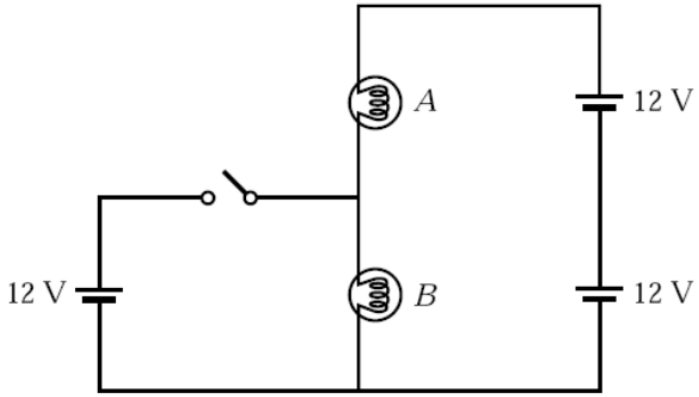
http://blog.metid.polimi.it/?p=446

- Focuses on **active learning** and **conceptual understanding**.

E. Mazur, Peer Instruction: A User's Manual, Upper Saddle River: Prentice Hall (1997).

DC Circuit (1st Attempt)

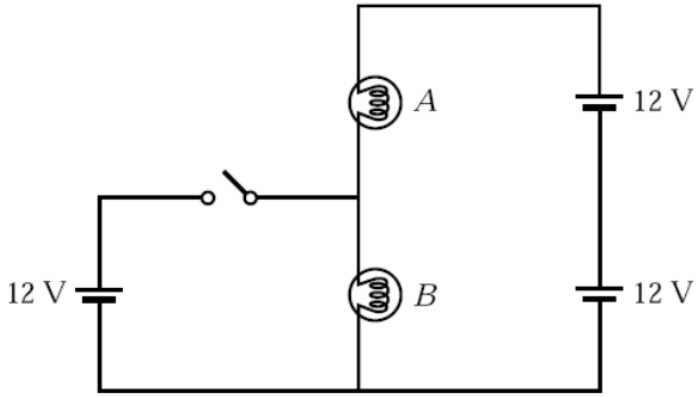
The light bulbs in the circuit are identical. When the switch is closed,



1. both go out.
2. the intensity of light bulb A increases.
3. the intensity of light bulb A decreases.
4. the intensity of light bulb B increases.
5. the intensity of light bulb B decreases.
6. some combination of 1–5 occurs.
7. nothing changes.

DC Circuit (2nd Attempt)

The light bulbs in the circuit are identical. When the switch is closed,

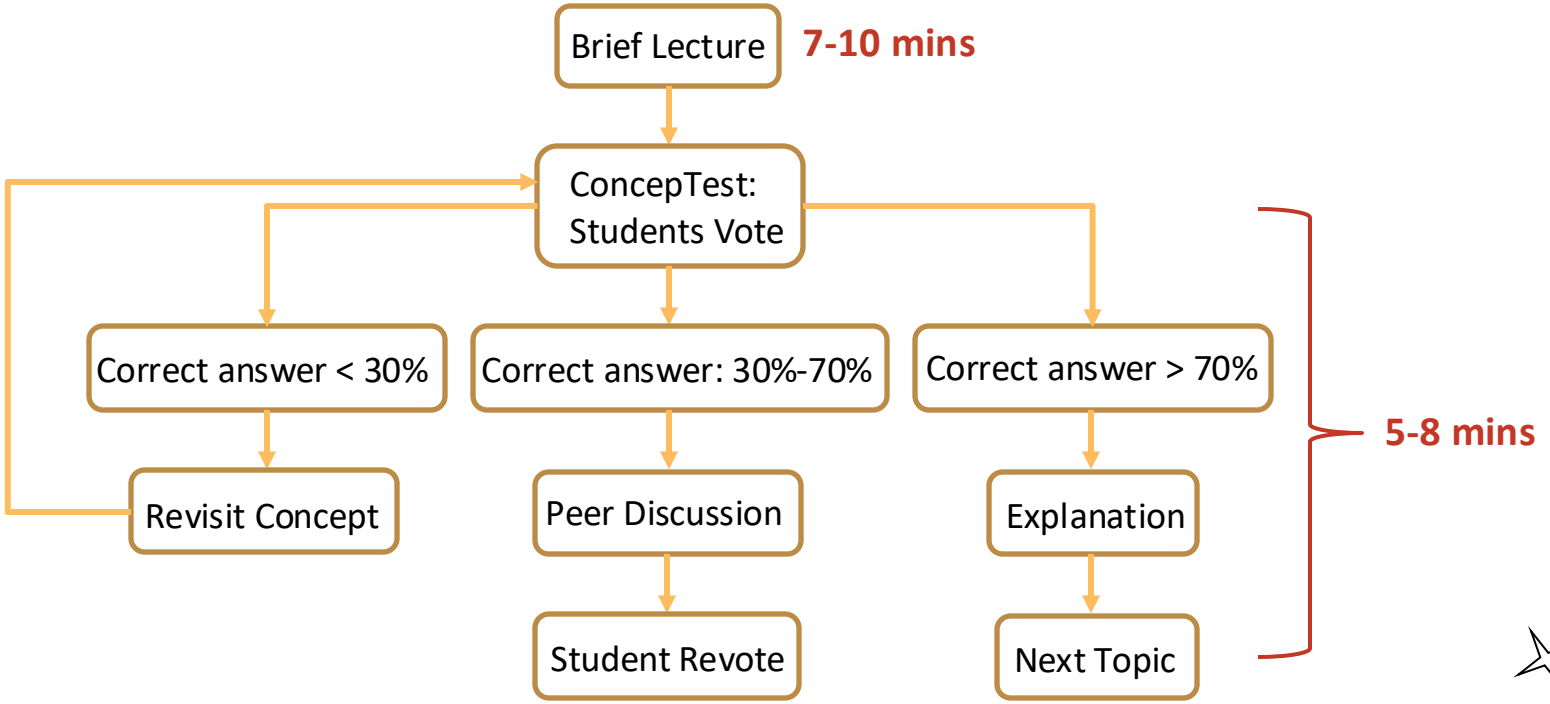


1. both go out.
2. the intensity of light bulb A increases.
3. the intensity of light bulb A decreases.
4. the intensity of light bulb B increases.
5. the intensity of light bulb B decreases.
6. some combination of 1–5 occurs.
7. nothing changes.

How PI Works?

1. Pose a Conceptual Question	• A challenging, **thought-provoking** question. • Typically multiple-choice.
2. First Poll	• Students respond **individually**. • Can use online polls, or raised hands.
3. Peer Discussion	• Students **discuss** their reasoning in pairs or small groups.
4. Second Poll	• Students **answer again** after discussion.

Implementation Process



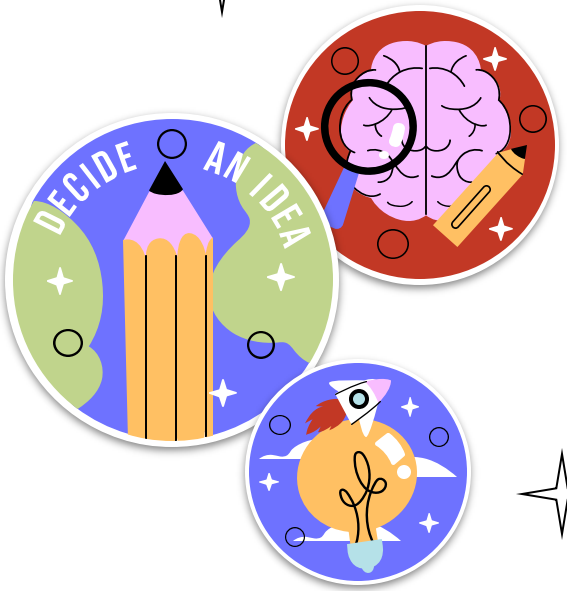
Lasry *et al,* American Journal of Physics, 76(11), 1066-69 (2008).

Why Use PI?

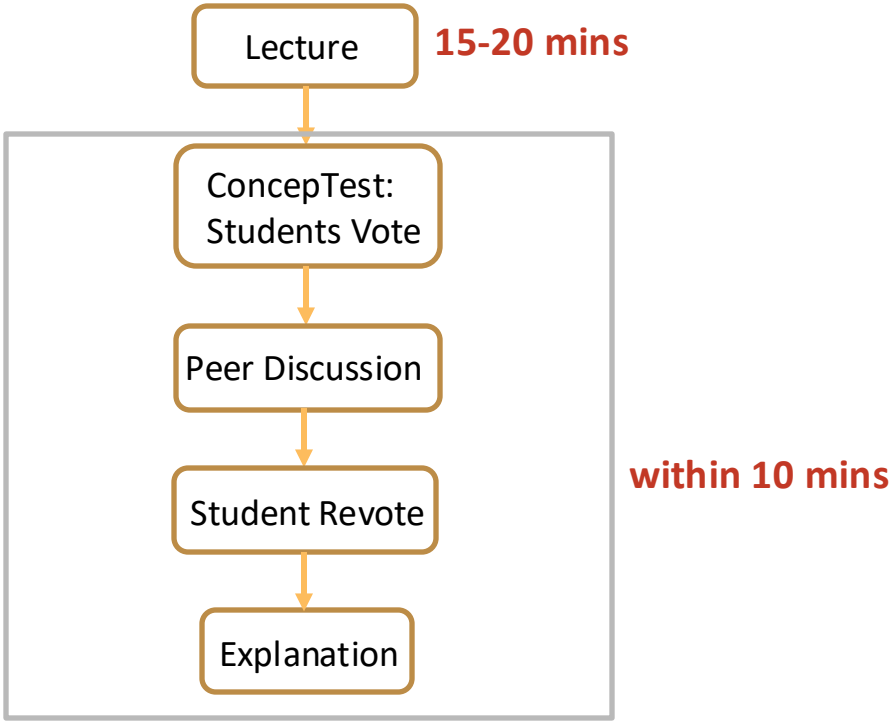
- **Promotes critical thinking** and deeper conceptual understanding.
- **Corrects misconceptions** through peer discussions and instructor’s explanation.
- **Improves retention** with active engagement.
- Instructors **gain better insight** into **students' learning progress.**
- Effective in classes with a **sizable** number of students.

PI in My Classroom

Course Title: General Physics (a)



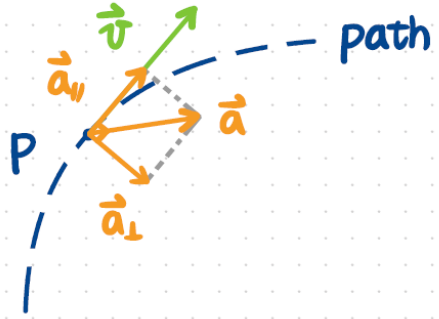
Implementation Process



Question Type 1: Conceptual Question

Tangential acceleration $\vec{a}_{\parallel}$

Normal acceleration $\vec{a}_{\perp}$



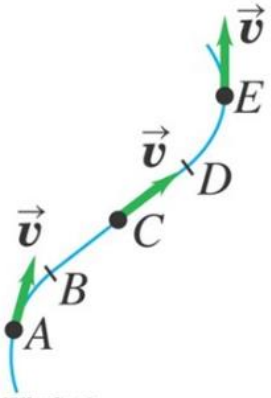
$\vec{a}_{\parallel}$ tells us about changes in particle's speed

$\vec{a}_{\perp}$ tells us about changes in particle's direction of motion

Question Type 1: Conceptual Question

Pre-Test: Acceleration

The motion diagram shows an object moving along a curved path at constant speed. At which of the points *A*, *C*, and *E* does the object have *zero* acceleration?



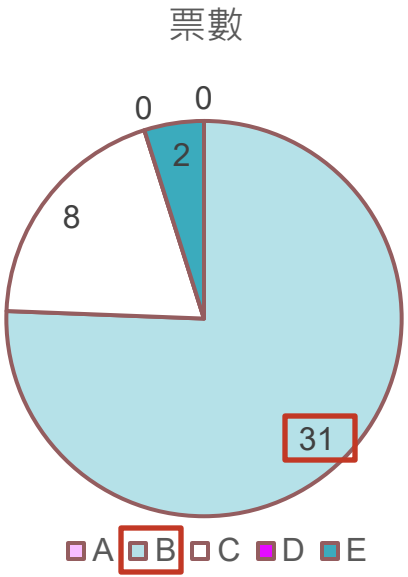
A. point *A* only

B. point *C* only

C. point *E* only

D. points *A* and *C* only

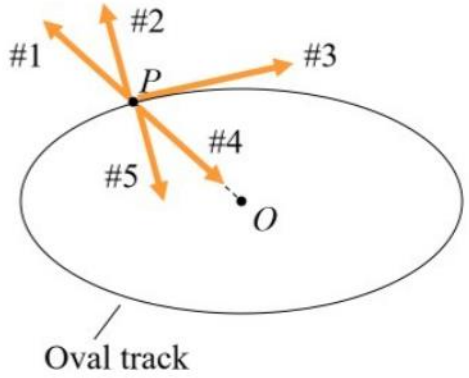
E. points *A*, *C*, and *E*



Question Type 1: Conceptual Question

Post-Test: Acceleration

An object moves at a constant speed in a clockwise direction around an oval track. The geometrical center of the track is at point *O*. When the object is at point *P*, which arrow shows the direction of the object's acceleration vector?



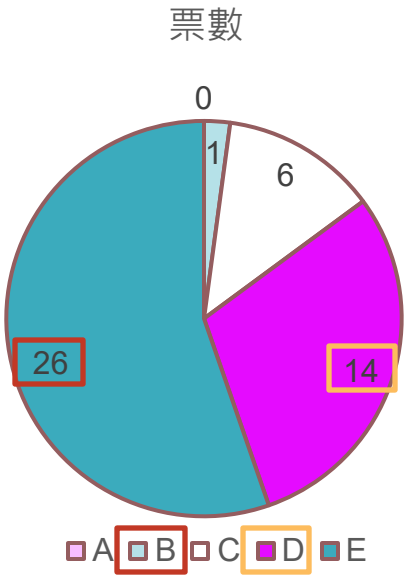
A. #1 (directly away from *O*)

B. #2 (perpendicular to the track)

C. #3 (in the direction of motion)

D. #4 (directly toward *O*)

E. #5 (perpendicular to the track)



Question Type 2: Calculation

WILEY

The Jensens decided to spend their family vacation white water rafting. During one segment of their trip down a horizontal section of the river, the raft (total mass = 500 kg) has an initial speed of 5.0 m/s. The raft then drops a vertical distance of 15.0 m, ending with a final speed of 15.0 m/s. How much work was done on the raft by non-conservative forces?

a) –12 500 J

b) –18 500 J

c) –23 500 J

d) –36 500 J

e) –48 500 J

Question Type 3: Laws or Theorems

問答題 記名 個人作答 可改答案多次交卷 編輯題目

開放作答

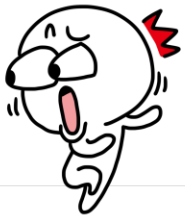
指定同學補考

排程

What are Newton's Laws of Motion?

3

E=mc^2



4

有三種運動的定律

1.物體保持運動狀態，除非有外力的作用下。

2.力等於質量乘以加速度。

3.每一個作用力都有一定有一個相等反向的反作用力。

Question Type 4: Compare Different Ideas

問答題 記名 個人作答 可改答案多次交卷 編輯題目

開放作答

指定同學補考

排程

What is the difference between a dimension and a unit?

22

Dimension 是方位，用來解釋位 向。unit是單位，用來說明純量的形式。

23

units are used to define the exact measurement of dimension. where Dimension is a physical quantity.

Students' Feedback

老師的講義簡單易懂，老師的ZUVIO題目也非常契合討論的範圍，建立同學的信心的同時又學習到新的觀念

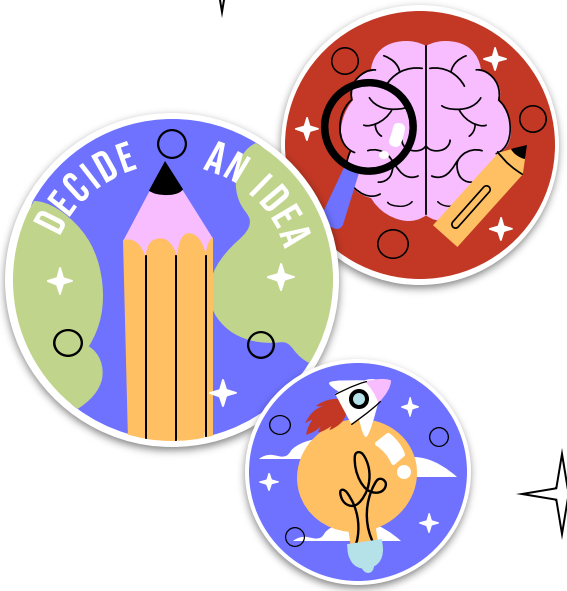
物理課整體的步調有點快，希望課堂上有更多時間讓我們吸收，但上課與同學討論問題的方法覺得很有效

老師課堂講話清晰，講義也準備的很用心，還會將每堂課錄影下來，也會透過即時測驗，讓我們能進一步了解上課內容。很喜歡老師會配合進度安排assignment，特別有助於督促我們學習普物，不會因為沒作業或小考就懈怠，而且作業的形式，讓我們有機會與同學討論解題的技巧或發現該注意的細節，也進一步了解自己是否有不懂的觀念。老師真的辛苦了！

教授的教學方式非常有條理，配合教授完整的筆記，對於我的物理學系很有幫助。課堂中教授也有出少許問題讓我們思考物理觀念並與同學討論，上課氣氛活絡，我也學到很多！

我沒有很喜歡那種課堂回答的app 因為那個真的很壓縮教學時間 但我知道那個對當下學習效果檢驗很有幫助啦

PI in
General Physics Experiment Course



Hu et al. (2015). Application of Peer Instruction in General Physics Experiment Course

Example Activity: *Measuring Sound Speed*

◆ **Pre-Class Conceptual Questions**:

1. Why can sound speed be measured using ultrasound in air?
2. How does the phase comparison method form an ellipse?
3. Why does increasing the transmitter–receiver distance reduce signal strength?

◆ **Instructional Flow**:

- Each question assigned to two groups
- Individual thinking → Group discussion → Cross-group sharing → Instructor clarification

◆ **Results**:

- Student accuracy improved from 22% → 86% →98% across discussion cycles.
- More than 85% of students reported increased interest in physics experiments.
- 95% believed PI enhanced focus and interaction.

Takeaway –Develop PI Questions

- **Objective** Encourage critical thinking and peer discussion.
- **To Do**:
  1. **Identify Key Concepts**: Focus on areas students found challenging.
  2. **Design Thought-Provoking Questions**:
     - Emphasize conceptual understanding rather than memorization.
     - Use common misconceptions as distractors to prompt debate.
  3. **Aim for Analysis and Reasoning**:
     - Require students to explain their reasoning or apply concepts to new scenarios.
     - Frame questions that stimulate deeper engagement beyond surface-level recall.

https://academyteachers.ucr.edu/sites/default/files/2020-05/writing-great-clicker-questions-nsf.pdf

Conclusion

- **Responsive Teaching:** PI create interactive and adaptive learning environments.
- PI works well for **concept-heavy subjects**; engage students with questions and peer discussions to deepen understanding.
- Empower Students: Help them **take ownership** of their learning through active participation.

Thanks!

Do you have any questions?

Email me: pyyang@ntu.edu.tw