USING CONCEPTUAL UNDERSTANDING PROCEDURES (CUPs) IN THE TEACHING OF MOTION

Pam Mulhall
Melbourne Graduate School of Education
University of Melbourne
pmulhall@unimelb.edu.au

Brian McKittrick
(formerly) Faculty of Education
Monash University
bmckittr@bigpond.net.au

Our keynote address with Professor Dick Gunstone on "Exploring student difficulties with mechanics and electricity" highlighted the value to students of being in physics classrooms where there is a focus on the development of conceptual understanding *before* introducing mathematical representations of phenomena. Teacher facilitated discussion of students' ideas about the physics in a situation is a key feature of these classrooms. The goal of these discussions is for students to develop their conceptual understanding through explaining their ideas and listening to those of their peers.

Some of the "conceptual" teachers in our study used Conceptual Understanding Procedures (CUPs) to promote their students' understanding of motion. A CUP is a teaching procedure that involves student discussion about a *qualitative* physics problem set in a real world context.

At the start of a CUP, each student is given a copy of the problem to be discussed on an A4 sheet of paper. This problem requires a diagrammatic response. After they have been given time to think about the problem, students then discuss their ideas in groups of three (or four if necessary) and try to reach consensus. Each small group records its response on an A3 sheet of paper, on which the problem is printed. These A3 sheets are then displayed at the front of the room and each small group explains and defends their response, the objective being to achieve a class consensus about the correct scientific answer. Examples of an A4 and A3 sheet are given at the end of this file.

This kind of classroom discussion has very positive benefits in terms of student engagement, as the following comments illustrate:

Student: Everyone usually got their say about what they thought was right and then we could question each other and we had to justify it ourselves … which sort of meant you had to understand it a bit better to be able to answer questions people asked you.

Student: Yeah, you had to actually think in class (laughs) … You had to do a lot of thinking to do it.

Teacher: I don't think it hurts to … [have] a touch of confusion. You often learn best when you realise there's something not quite right there …

Teacher: At the end of class they did not want to leave until they had the right answer.

For this kind of discussion to be successful, an atmosphere of trust is important. Each student needs to feel their contributions to the discussion are valued. As one teacher noted:

Teacher: [The second CUP] was easier because they … knew there wasn't going to be that embarrassing [feeling of] 'I'm going to be put on the spot, I'm going to be laughed at because I really don't know what I'm doing'.

Each of the stages of a CUP described above has its own benefits, as the student and teacher quotes below illustrate:

1. Working alone (individual phase)

Student: Normally when we get asked something most people don't think about it. They just say, 'We don't know' and you get told [the answer] but in CUPs you've got time to think about it.

2. Working in groups of three or four (triplet phase)
Student: If we were just in one big group then I'm sure people wouldn't say anything. With the triplets you had to say something.

3. Whole class interpretive discussion
Student: It's not intimidating because it's a combined opinion on your A3.

Teacher: The thing I felt was so different about this was … that you actually got to hear what the kids were thinking whereas in a normal class discussion [you leap on] the first person that [says] something right … and you tend to ignore anything they come up with that's not quite right …

Some teachers worry that the class will reach a consensus that is 'wrong' from a physics standpoint. Our experience is that this rarely is the case. Should it occur, teachers will be better able to design follow-up lessons that further student understanding because of the insights they have gained into students' difficulties. Furthermore, the students have invested a lot of time thinking about the issues involved and will be *very* keen to learn the 'correct' answer!

Finally, both students and their teachers find CUPs very enjoyable. As one teacher commented, *I was delighted, absolutely delighted. At recess [when the bell rang] they were still going, no-one moved …*

FURTHER INFORMATION ON CUPs

1. **Downloadable examples** of CUP exercises and detailed advice for using them are available at:

   http://www.education.monash.edu.au/research/groups/smte/projects/cups/

2. McKittrick, B., Mulhall, P., & Gunstone, R. (1999). Improving understanding in physics: An effective teaching procedure. *Australian Science Teachers' Journal, 45*(3), 27 - 33.

3. Mills, D., McKittrick, B., Mulhall, P., & Feteris, S. (1999). CUP: cooperative learning that works. *Physics Education*, *34*(1), 11 - 16 *

4. There is an article on CUPs on the *PEEL in Practice* CD. Information on PEEL (Project for Enhancement of Effective Learning) and the CD is available at http://peelweb.org/index.html

5. If you have any queries, please email Pam Mulhall at pmulhall@unimelb.edu.au

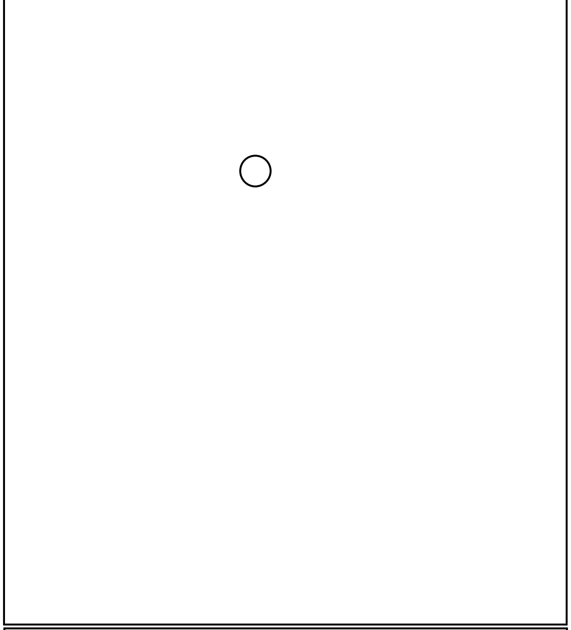
* Can be accessed for free at http://www.iop.org/EJ/physed

Ex 4 Dropping a *golf ball* and a *foam ball*

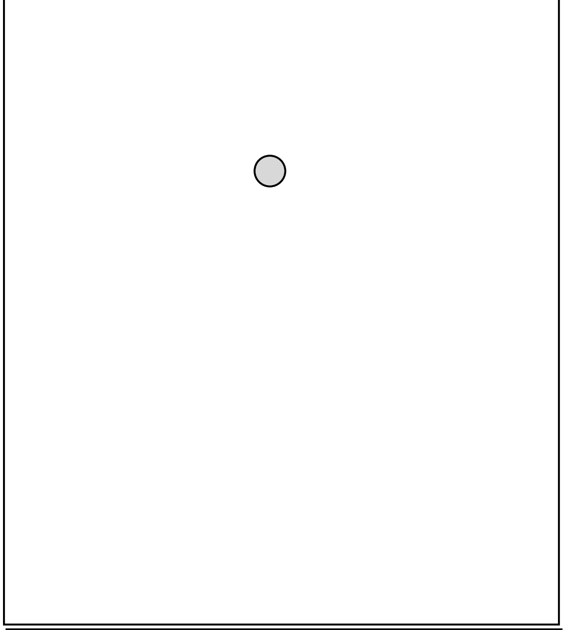
A **golf ball** and a lighter **foam ball** are dropped from the same height.
On the diagrams below draw the **individual forces** acting on each ball
(a) **early in the fall** and
(b) **later in the fall** but before they hit the ground.

Represent forces
- by drawing lines with arrowheads, e.g. →
- with the **length** of the line representing the **size** of the force,
- with the same scale for all forces,
- using as large a scale as possible,
- with the **tail** of each force at the point where the force acts,
- labelling forces, e.g. the force exerted **on** the **B**all (**B**) **by** the **E**arth (**E**) would be labelled $\mathbf{F_{BE}}$.

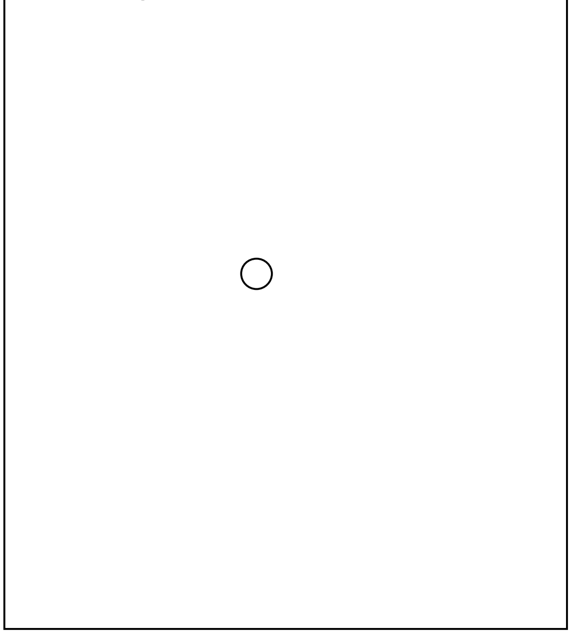
golf ball - *early* in fall



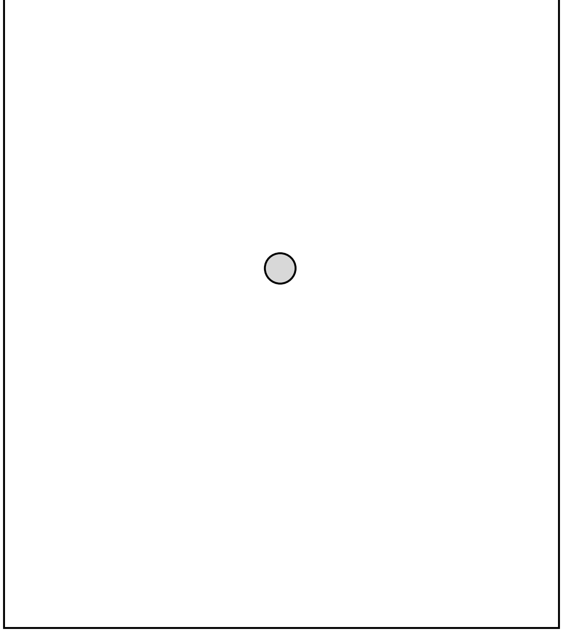
foam ball - *early* in fall



golf ball - *late* in fall



foam ball - *late* in fall



A3 sheet

Ex 4 Dropping a *golf ball* and a *foam ball*

Names

golf ball - *early* in fall

foam ball - *early* in fall

golf ball - *late* in fall

foam ball - *late* in fall