

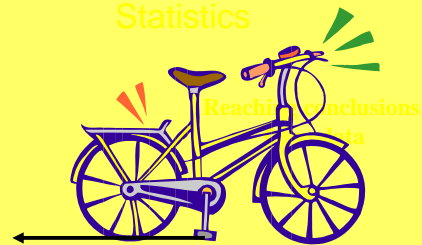
Concept Questions in Mechanics

Ted Graham
Centre for Teaching Mathematics
University of Plymouth

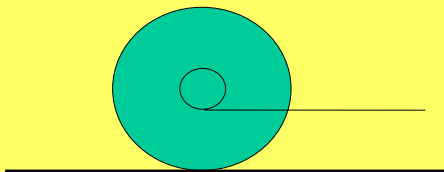


Which way will the bike move ?

Statistics



Which way will the drum move ?



Learning Outcomes in Mechanics

- Undisturbed Outcome
- Dual Perspective Outcome
- Incorrectly Reinforced Outcome
- Mixed Outcome
- Unified Outcome

Question Used in Research

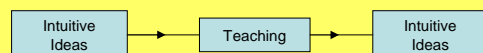
1 kg

3 kg

How does the time taken to fall compare ?

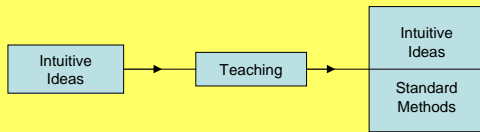
On Earth ? On the Moon ?

Undisturbed Outcome



	Same time	3kg is 3 times faster	3kg faster	Other
Before Teaching	54%	16%	26%	4%
After Teaching	57%	19%	20%	4%
Large Scale Survey	54%	18%	25%	2%

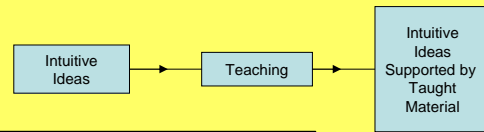
Dual Perspective Outcome



Use intuitive thinking when a concept question is posed.

Could calculate the time taken for balls of any mass to fall a prescribed distance.

Incorrectly Reinforced Outcome

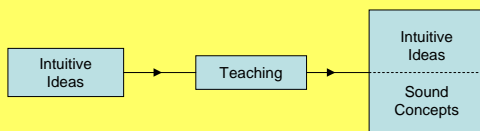


	3kg is 3 times faster	3kg faster
Before Teaching	16%	26%
After Teaching	19%	20%

"3:1 the 3kg ball gets there faster."

The 1kg ball will hit after the 3kg ball, because the gravitational pull is acting on only 1kg instead of 3kg."

Mixed Outcome

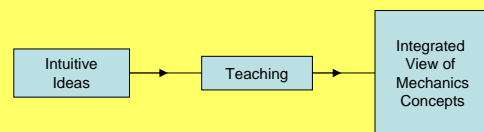


	Same Time	3kg First	Float	Other
Earth	54%	43%	0%	2%
Moon	56%	31%	8%	6%

"The balls would not fall as there is no force of gravity pulling them downwards."

"They would be affected by weightlessness, so they should be the same."

Unified Outcome



What Does This Research Tell Us ?

- Students' intuitive reasoning needs to be challenged.
- Students' reasoning can be strongly influenced by the context. Hence the idea of **Dominant Features**.
- Students' intuitive ideas may be triggered by the question. Hence the idea of **Spontaneous Reasoning**.

Parallel Questions Strategy

- Present a question in which you expect the students to reason incorrectly.
- Present a parallel question in which you expect the students to reason correctly.
- Draw the students' attention to the common features of the situations, rather than the dominant features.

Use of Parallels 1

A ball is thrown so that it moves vertically upwards.
In what direction does the resultant or overall force on the ball act?



Upwards	53%
None	1%
Downwards	33%
Other	13%

Use of Parallels 1 (cont.)

In what direction does the force act on a car that has applied its brakes while moving on a horizontal surface?



Dominant Feature: Direction of Motion

Common Feature: Slowing Down

Use of Parallels 2

A car is overtaking a lorry.
Does the car ever have the same speed as the lorry?

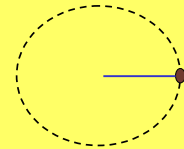
A car is overtaking a parked lorry.
Does the car ever have the same speed as the lorry?

Use of Parallels 3



In what direction is the resultant force on a car travelling at constant speed around a roundabout?

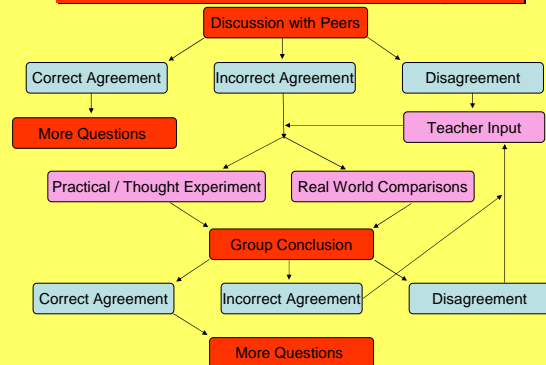
A conker describes a circle at a constant speed on the end of a piece of string. In what direction is the resultant force on the conker?



Using Concept Questions

- Use frequently
- Have a strategy
- Think about dominant features and spontaneous reasoning
- Have follow up questions
- Encourage students to ask their own questions

Use of Questions Diagram

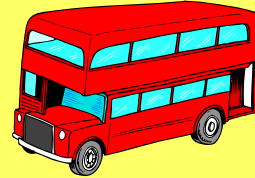


Concept Questions

- Concept questions are designed to test understanding rather than skills.
- Can be used as an opening mental activity for lessons.
- They do not need to be a major part of the lesson.

A person steps off a moving bus.

What happens to them ?

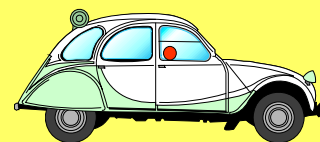
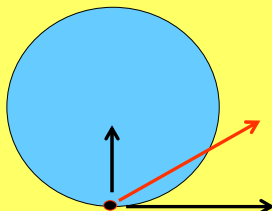
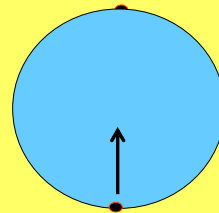


Model the person as a rod



Friction has an effect !!!

Two children are on a roundabout in a park.
The roundabout is rotating.
One child throws the ball directly towards the other.
Does the child catch the ball ?



A ball is dropped out of the
window of a moving car.
Where does it land ?
Draw the path of the ball.

The Path of The Ball

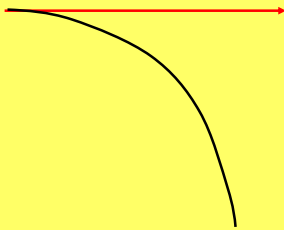


The Path of The Ball



If the car is slowing down.

If the car is going round a bend.



Sources of Concept Questions

- Exploring Mechanics
- Your Own Ideas
- Your Students

From Exploring Mechanics

My friend says:
"My dog does not need dog bars to keep it in the back. It stays pinned to the back door if I go fast enough!"
Do you agree? Why?



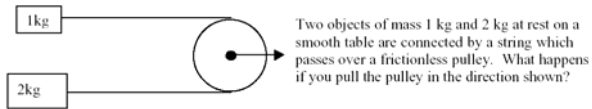
From Exploring Mechanics

A spaceship in deep space, where no forces are acting on it, drifts sideways from X to Y. When it reaches Y it fires its engines for a short time, turning them off when it reaches Z.

Draw a possible path that the spaceship could follow from Y to Z and then beyond Z.



From Exploring Mechanics



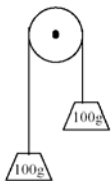
Two objects of mass 1 kg and 2 kg at rest on a smooth table are connected by a string which passes over a frictionless pulley. What happens if you pull the pulley in the direction shown?

From Exploring Mechanics

Two boys try to stretch a spring using the two methods shown in the diagram.
By which method is it easier to stretch the spring?



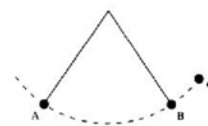
From Exploring Mechanics



Two identical objects are connected to the ends of a light inelastic string which passes over a fixed pulley as shown.

What happens if the system is released from rest?

From Exploring Mechanics

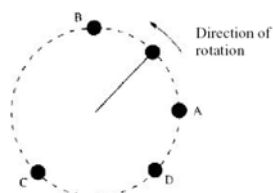


The pendulum in the diagram swings from left to right through the points A and B.

Copy the diagram and mark on it arrows to show the forces acting on the pendulum bob at these positions. (Ignore air resistance in this problem.)

What happens if the string is cut when the pendulum bob is (a) at B or (b) at C? (C is the highest point.)

From Exploring Mechanics



A small object attached to one end of a string is swung around in a vertical circle.

What will happen if the string is cut when the object is at

- (a) point A,
- (b) point B,
- (c) point C,
- (d) point D?