Angular Momentum : A practical approach

ROTATION

- Introduce by a contextual approach, e.g. the bicycle, a roller, wheels etc.
- Revise Year 12 Circular Motion.
- Develop equations for θ, ω and α.
- Develop equations involving θ, ω and α. (equiv to kinematic equations)
- Define Torque(τ), establish Torque $\propto$ Angular accln (α) using a flywheel and smart pulley (or ticker-timer) or video analysis.

RELATIONSHIP BETWEEN MOMENT OF INERTIA AND ANGULAR MOMENTUM

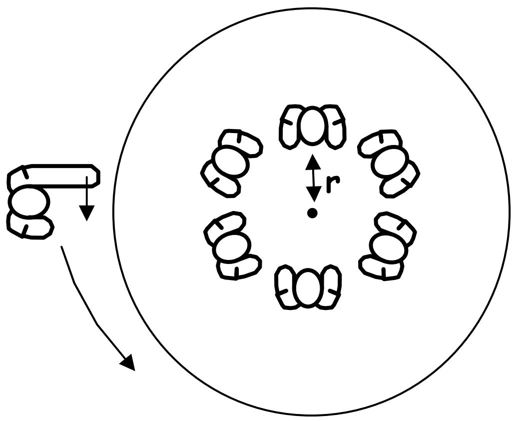
PRACTICAL EXERCISE – The Merry-Go-Round

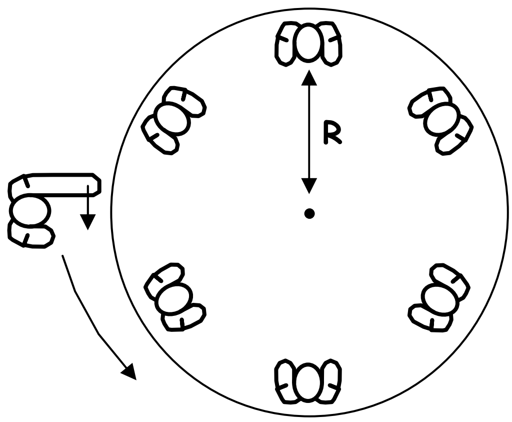
What you need :
- one free-spinning merry-go-round
- at least six students
- a portable white board (or newsprint)
- a digital still with MPEG facility or video camera for later analysis

AIMS OF THE PRACTICAL

1. **To show Linear Momentum can be converted to Rotational Momentum**

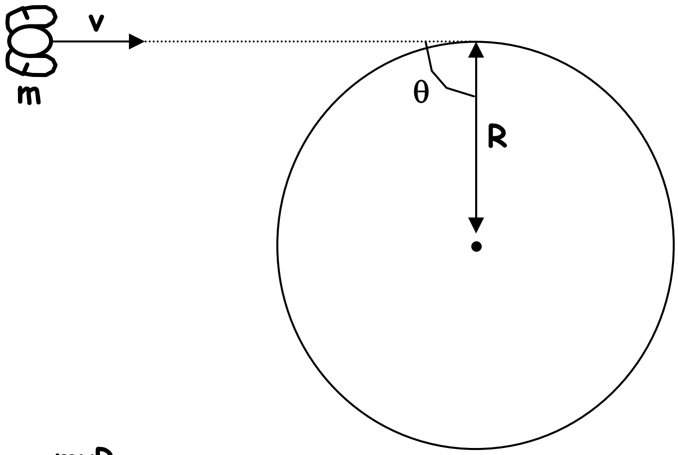
Setting Part A





- Get each student to rotate the merry-go-round with two different mass distributions, this is to give them the **'feel'** of the relationship between applied torque and angular acceleration.

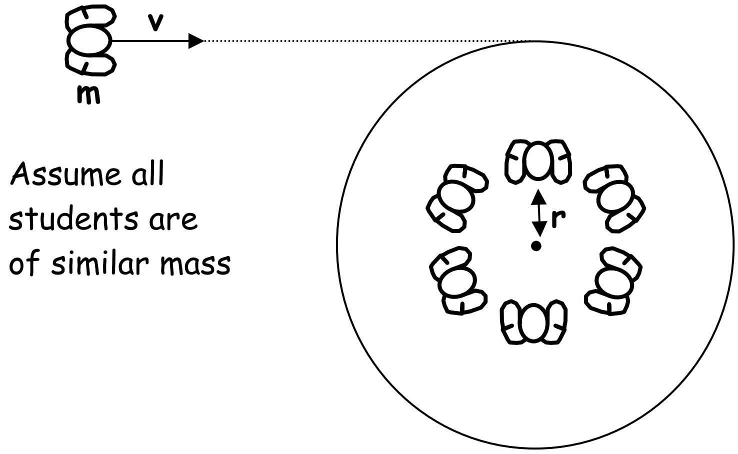
Part B



- Define **p = mv** and **L = mvR.**
- Try different speeds (v) /same student / at 90° to **R**
- Try different students (m) / same speed / at 90° to **R**
- Try angles up to 90° / same speed / same student
- Try different **R** values / same student / same speed
- Show L $\propto$ angle to R
  - $\propto$ Mass (m)
  - $\propto$ incoming momentum (p)
  - $\propto$ radius (r)
  - } **L=mvR** if $\theta = 90°$

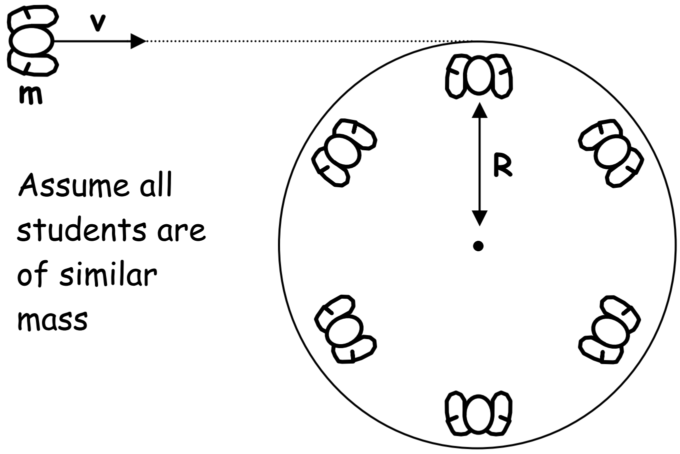
2. To investigate Mass Distribution and Angular Momentum

Setting **Part A**



- Place six students near the centre / same incoming momentum / observe resulting angular speed of the merry-go-round.

Part B



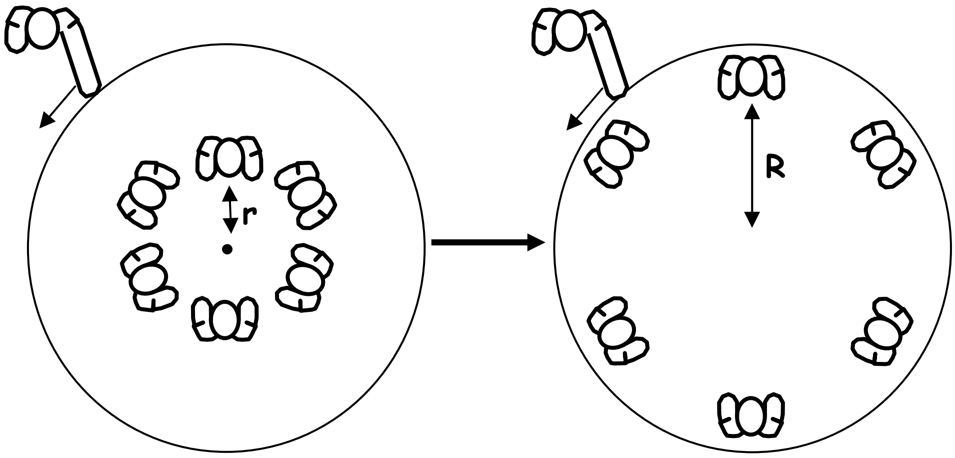
- Move the six students to the outside / same incoming momentum / observe resulting angular speed of the merry-go-round.
- Show angular velocity reduces even though the initial angular momentum was the same in each case – discuss 'idea' conservation of angular momentum.
- Define a new quantity : I - Angular momentum

  $\propto$ mass

  $\propto$ mass distribution

3. To investigate Conservation of Angular Momentum

Setting



- Start with six students at radius **r** / rotate to a high ω / instruct students to move to radius **R** at the same time / observe ω.

- Try to reverse moving students from radius **R** to **r (make sure you start this exercise with a LOW ω as the resulting increase in speed is spectacular)**
- Show as R increases then ω reduces and vice versa i.e. $\mathbf{L}_{\text{before}} = \mathbf{L}_{\text{after}}$

Follow-up in class :

1. Relate results from the Torque $\propto$ angular acceleration experiment to the idea of rotational inertia (i.e. slope of the graph of $\tau \propto \alpha$)

2. Show a video of an ice skater doing a pirouette or a karate expert doing a kick turn manoeuvre.

3. Use rotating stool and masses to revise conservation of angular momentum. (see picture below)

4. Use a rotating stool and spinning bike wheel to do the same, i.e. orientation changes of the bike wheel.

5. Construct an efficient spinning top.