YEAR 12

PHYSICS (STAGE 3)

CIRCULAR MOTION TEST

Student's Name: | Tutorial Group:

Teacher's Name: | Date:

- **Motion** is a continuous change in position.
- **Uniform circular motion** is motion in a circle at constant speed **v**.
- When any object undergoes **uniform circular motion**, the magnitude of its velocity (or speed **v**) remains constant, and the direction of its velocity changes continuously.
- As **acceleration** is defined as the rate of change of velocity, a continuous change in direction constitutes acceleration, just as a change in the magnitude of the velocity (or speed **v**) does.

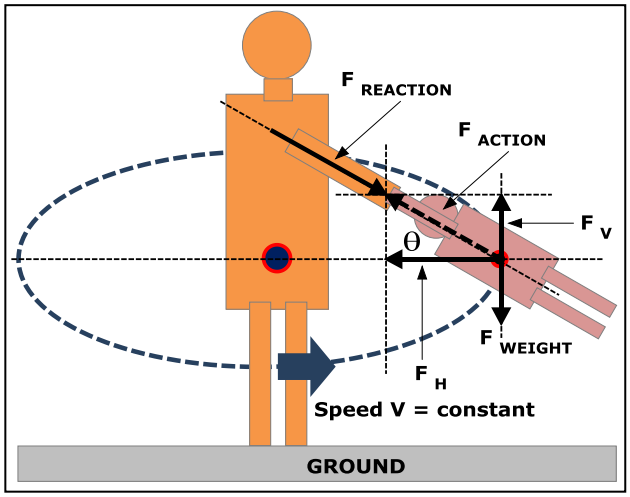
Swinging a Child in a Horizontal Circle

1. Why is a child being swung, at constant speed, in a horizontal circle undergoing uniform acceleration?

[4 marks]

We can draw a **free-body diagram** to illustrate some selected forces acting as the man swings the child.

- **Free-body diagrams** are diagrams used to show the relative magnitude and direction of all forces acting upon an object in a given situation, like a child swung in a horizontal circle at constant speed **v**.



An analysis of the Free-body diagram

- The **action force** is the force exerted by the man on the child.
- The **reaction force** is the force exerted by the child on the man.
- The action force has been resolved into two rectangular components at **90 ^{0}** to each other.
- The child's weight force acts through his/her **centre of gravity**.

Any air resistance acting on the child would be negligible, i.e., it would be so small, it can be ignored.

- **Newton's Third of Motion** can be stated as follows: If object **B** exerts a force (F) on object **A**, object **A** exerts an equal but oppositely directed force (– F) on object **B**.

2. In what way is the reaction force **F REACTION** the **same as** the action force **F ACTION**?

[1 mark]

3. In what way is the reaction force **F REACTION** **different from** the action force **F ACTION**?

[1 mark]

Resolution of action Force

The free-body diagram shows that the action force has been resolved into two rectangular component vectors: vertical **F V** and horizontal **F H**, which when added together have the same effect as the action force, which they have replaced.

4. How does the free-body diagram show that the action force **F ACTION** has been replaced?

[1 mark]

5. There are only **two original forces** acting on the child being swung in a horizontal circle at constant speed **v**. What are names of these two forces?

[2 marks]

6. What **mathematical equation** can be used to calculate the size of the vertical component $\mathbf{F_V}$?

[2 marks]

7. What does the vertical component of the action force $\mathbf{F_V}$ do for the child? What is the effect of $\mathbf{F_V}$?

[3 marks]

8. What **mathematical equation** can be used to calculate the size of the horizontal component $\mathbf{F_H}$?

[2 marks]

9. What does the horizontal component of the action force $\mathbf{F_H}$ do to the child? What is the effect of $\mathbf{F_H}$?

[3 marks]

10. Why is the child swung in a horizontal circle, at constant speed, undergoing constant acceleration?

[4 marks]

Centripetal Force

- According to Newton's second law of motion $\mathbf{\Sigma F = ma}$, an object that is accelerating must have a resultant force acting on it. Any object moving in a circular path must therefore have a force applied to it to keep it moving in that circular path.

- The resultant force $\mathbf{\Sigma F_C}$ giving centripetal acceleration $\mathbf{a_C}$, to the object, can be calculated using this physics formula: $\mathbf{\Sigma F_C = m \times a_C = m \times (v^2 / r)}$

11. Is the child swung at constant speed **v**, in a horizontal circle, being acted upon by a resultant force **F**? If so, can you name the force?

[2 marks]

Mechanical Equilibrium

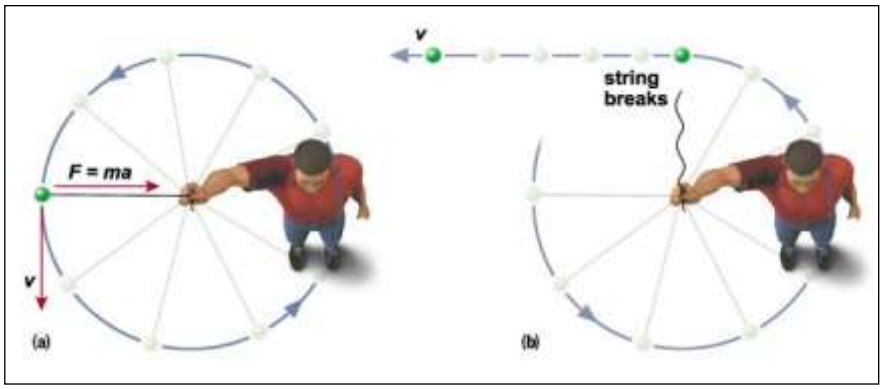
- An object in **mechanical equilibrium** is either at rest, or moving with a constant velocity.

12. Is the child swung at constant speed, in a horizontal circle, in a state of **mechanical equilibrium**? You must answer either yes or no, and then fully explain your answer.

[4 marks]

Circular Motion and a Common Misconception

A common misconception in physics is that an object moving in a circle has an outward force acting on it, referred to as the centrifugal or ("centre-fleeing") force. This is incorrect as there is no outward force on a revolving object.



13. How does Image (b) show that there is no outward force acting on the (green) ball?

[2 marks]

Numerical Problem Solving

14. The moon of mass of **7.30 × 10 22** kg orbits the Earth in a circular orbit of radius **1.74 × 10 6** m, once every **29.5** days. Can you calculate the: (a) orbital speed (m s^{-1}); (b) centripetal acceleration (m s^{-2}), and centripetal force (N) needed to keep the moon in its orbit?

Q14 (a) [3 marks]: (b) [3 marks], and (c) [3 marks]

[Total marks = 40]

Percent score =