Measuring and Calculating Motion

Name ______________________________

Class ______________________________

Teacher ______________________________

L1 Scalar and vectors

Scalar Quantities

A scalar quantity is something that only has a size or magnitude. It doesn't have any direction. Here are some examples:

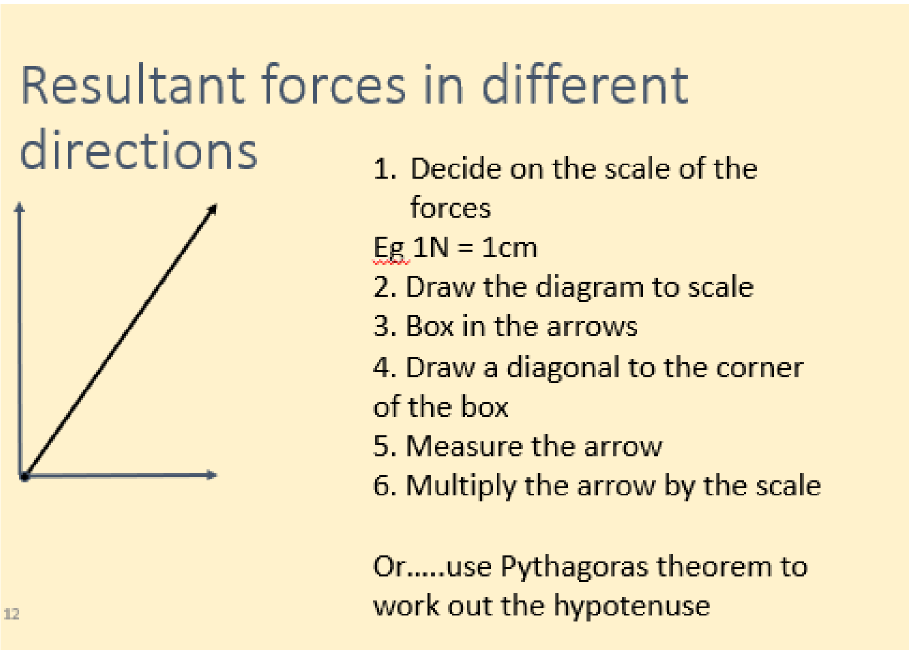
- Temperature: If it's 30 degrees Celsius outside, that's just a number with no direction.
- Speed: If you're driving at 60 km/h, you know how fast you're going, but not in which direction.
- Mass: If something weighs 10 kilograms, that's just how heavy it is, without any direction.

Vector Quantities

A vector quantity has both a size (magnitude) and a direction. Think of it like an arrow that shows you how much and which way. Here are some examples:

- Velocity: If you're moving at 60 km/h to the north, you have both a speed (60 km/h) and a direction (north).
- Force: If you push something with a force of 10 newtons to the right, that's a vector because it tells you how strong the push is and in which direction.
- Displacement: If you walk 5 meters to the east, this tells you how far and in what direction you moved.

Resolving a Vector



Independent practice

1. Which of the following is a scalar quantity and why?

   - A) 50 km/h

   - B) 50 km/h to the east

2. What information do you need to describe a vector quantity that you don't need for a scalar quantity?

3. If you push a box with a force of 20 newtons to the north, what type of quantity is this and why?

4. Give an example of a situation where you might need to know both the magnitude and the direction of a quantity. What type of quantity would this be?

5. Resolve a vector with a magnitude of 15 N North and 20N East

6. Resolve a vector with a magnitude of 40N west and 12N South

L2 Weight

Weight

Weight is the force exerted by gravity on an object. It depends on both the mass of the object and the gravitational pull of the place where the object is. Weight is measured in Newtons (N)

To calculate weight we use the formula: **Weight = Mass x Gravity field strength**

W =mg

On Earth, the gravitational field strength is approximately 9.81 m/s^2

Key Differences between mass and weight

- Constancy:
  - Mass is constant everywhere.
  - Weight changes with gravity.
- Measurement:
  - Mass is measured in kilograms (kg).
  - Weight is measured in newtons (N).
- Conceptual Difference:
  - Mass is like counting how many atoms are in an object.
  - Weight is how strongly those atoms are pulled by gravity.

Independent practice

1. What is mass and how is it different from weight?

2. Why does the weight of an object change when it is taken to the Moon, but its mass stays the same?

3. What is the standard unit of mass and weight?

4. Explain why an astronaut feels weightless in space.

5. If you were to travel to a planet with twice the gravity of Earth, how would your mass and weight change?

6. How would your weight change if you travelled to the centre of the Earth?

7. Why is it incorrect to say that your mass is '70 kilograms' on Earth but '12 kilograms' on the Moon?

8. What role does gravity play in determining the weight of an object?

Calculation Questions

9. Calculate the weight of a 5 kg object on Earth ($g = 9.8\ m/s^2$).

10. Calculate the weight of the same 5 kg object on the Moon ($g = 1.6\ m/s^2$)

11. Calculate the mass of an object if its weight is 98 N on Earth.

12. Calculate the weight of a 7 kg object on Mars ($g = 3.7\ m/s^2$).

13. Find the gravity on a planet where a 10 kg object weighs 250 N.

14. Calculate the weight of a 12 kg object in space if the gravity is $0.5\ m/s^2$.

15. Calculate the mass of an object if its weight is 30 N on the Moon ($g = 1.6\ m/s^2$).

16. Calculate the weight of a 20 kg object on Jupiter ($g = 24.8\ m/s^2$).

More Calculation Questions

17. Find the mass of an object if it weighs 500 N on a planet with gravity $5\ m/s^2$.

18. Calculate the weight of a 50 kg object on Venus ($g = 8.87\ m/s^2$).

19. Calculate the mass of an object if its weight is 15 N in space where gravity is $0.75\ m/s^2$.

20. Find the weight of a 30 kg object on a planet where gravity is $12\ m/s^2$.

L3 Work Done

Work is done when a force causes an object to move in the direction of the force. In other words, if you push or pull something and it moves because of that push or pull, you've done work on it.

Work Done = force x distance

W=Fs

- Work is measured in joules (J).
- Force is the push or pull applied to the object, measured in newtons (N).
- Distance is how far the object moves in the direction of the force, measured in meters (m).

Key Points

-If the force is not in the direction of the movement, only the part of the force that is in the direction of the movement does work.

- No Movement, No Work: If the object doesn't move, no matter how much force you apply, no work is done.

- Units: The unit of work is the joule (J). One joule is the work done when a force of one newton moves an object one meter in the direction of the force.

Summary

- Work is a measure of the energy transferred by a force to move an object.

- It depends on the magnitude of the force, the distance the object moves, and the direction of the force relative to the movement.

- Understanding work helps explain how forces cause objects to move and how energy is transferred in physical processes.

Independent practice

1. What is the definition of work done in physics?

2. What is the unit of work, and how is it related to force and distance?

3. Explain why no work is done if an object does not move, even if a force is applied.

4. How does the angle between the force and the direction of movement affect the work done?

5. Describe a scenario where a force is applied, but no work is done.

6.Why is the work done zero when the force is perpendicular to the direction of movement?

7. What is the significance of the cosine term in the work done formula?

8. If you carry a heavy object at a constant height while walking forward, are you doing any work on the object? Explain why or why not.

Calculation Questions

9. Calculate the work done when a 10 N force moves an object 5 meters in the direction of the force.

10. Calculate the work done if a 20 N force moves an object 3 meters at an angle of 60° to the direction of the force.

11. Determine the force applied if 100 J of work is done to move an object 4 meters in the direction of the force.**

12. Calculate the distance an object is moved if 75 J of work is done by applying a 15 N force in the direction of the force.

13. Calculate the work done if a 50 N force moves an object 10 meters at an angle of 45° to the direction of the force.

14. Find the angle between the force and the direction of movement if a 30 N force does 60 J of work over 3 meters.

15. Determine the work done if a 25 N force moves an object 7 meters horizontally while the force is applied at an angle of 30° to the horizontal.

16. Calculate the force needed to do 200 J of work over a distance of 5 meters at an angle of 60° to the direction of the force.

17. Find the distance an object moves if a 40 N force at an angle of 30° does 160 J of work.

18. Determine the work done when a 15 N force is applied at an angle of 90° to the direction of movement over a distance of 5 meters.

19. Calculate the force applied if 500 J of work is done to move an object 10 meters at an angle of 45° to the direction of the force.

20. Find the angle between the force and the direction of movement if a 60 N force does 180 J of work over 5 meters.

L4 Speed time graphs

A speed-time graph shows how the speed of an object changes over time. Here's how to understand and interpret them:

Gradient

- The gradient of the graph indicates the acceleration or deceleration of the object.
- A steeper gradient indicates a greater rate of change in speed 9acceleration).

Horizontal Line:

- Represents constant speed.
- The object is moving at a steady speed because the speed does not change over time.

Upward Sloping Line:

- Represents increasing speed (acceleration).
- The object is speeding up over time.

Downward Sloping Line:

- Represents decreasing speed (deceleration).
- The object is slowing down over time.

Curved Line:

- Represents changing acceleration.
- The rate of speed change is not constant.

Areas Under the Graph

- The area under a speed-time graph represents the distance travelled.

<u>Independent practice</u>

1. Explain what a horizontal line on a speed-time graph indicates about the motion of an object.

2. A car accelerates from rest to a speed of 20 m/s in 5 seconds. It then travels at a constant speed for 10 seconds before decelerating to a stop in the next 5 seconds.

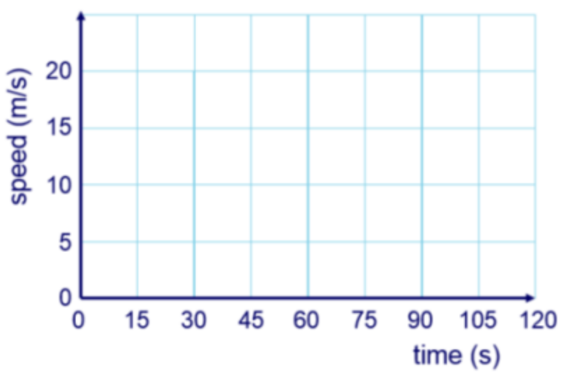
a. Draw the speed-time graph for this motion.

b. Calculate the total distance traveled by the car.

3. Describe the motion of an object represented by a speed-time graph that has an upward sloping line for the first 4 seconds, a horizontal line for the next 6 seconds, and a downward sloping line for the final 4 seconds. Calculate the total distance if the object accelerates to 12 m/s in the first phase, maintains this speed, and then decelerates to a stop.

Q4)

In a race, a cyclist accelerates to a speed of 20 m/s in 30 seconds. She then travels at a constant speed for 90 seconds before crossing the finishing line.



(a) What is her acceleration during the first 30 seconds ?

(b) What is the length of the race in metres ?

L5 Acceleration 1

- Acceleration is the rate at which an object changes its velocity. It tells us how quickly an object speeds up, slows down, or changes direction.

$$Acceleration = \frac{Change\ in\ velocity}{time}$$

where:

-a is acceleration.

-change in velocity is the final velocity minus the initial velocity.

- t is the time over which the change occurs.

- Acceleration is measured in meters per second squared (m/s^2).

- Key Points

- It can be positive (speeding up) or negative (slowing down).

- It is calculated as the change in velocity divided by the time over which the change occurs.

- Understanding acceleration helps explain how objects move and respond to forces.

Independent practice

1. Calculate the acceleration:

   - A car's velocity changes from 10 m/s to 30 m/s in 5 seconds. What is the car's acceleration?

2. Determine the final velocity:

   - A car accelerates at 3 m/s^2 for 4 seconds. Its initial velocity was 10 m/s. What is the final velocity?

3. Find the initial velocity:

   - A car accelerates at 5 m/s^2 for 6 seconds, reaching a final velocity of 40 m/s. What was its initial velocity?

4. Calculate the time taken:

   - A car accelerates from 15 m/s to 35 m/s at a rate of 4 m/s^2. How much time does it take?

5. Find the acceleration: - A car's velocity increases from 20 m/s to 50 m/s over a distance of 150 meters.

6. **Determine the distance travelled:**

   - A car accelerates from rest at a rate of 6 m/s^2 for 8 seconds. How far does it travel?

7. Calculate the time taken:

   - A car decelerates from 60 m/s to 20 m/s at a rate of -8 m/s^2. How long does it take?

8. Find the final velocity:

   - A car starting from rest accelerates at 4 m/s^2 over a distance of 100 meters. What is its final velocity?

L6 Acceleration 2

Uniform acceleration

$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$

$$v^2 - u^2 = 2\,a\,s$$

a = m/s^2
v = m/s
u = m/s
s = m

Independent practice

1. Calculate the acceleration when the initial velocity is 10 m/s, the final velocity is 30 m/s, and the distance is 100 meters.
2. Calculate the acceleration when the initial velocity is 0 m/s, the final velocity is 50 m/s, and the distance is 250 meters.
3. Calculate the acceleration when the initial velocity is 5 m/s, the final velocity is 25 m/s, and the distance is 80 meters.
4. Calculate the acceleration when the initial velocity is 15 m/s, the final velocity is 45 m/s, and the distance is 200 meters.
5. A car accelerates from 20 m/s to 60 m/s over a distance of 300 meters; calculate the acceleration.
6. A cyclist increases their speed from 8 m/s to 40 m/s over a distance of 150 meters; calculate the acceleration.
7. A train accelerates from 12 m/s to 42 m/s over a distance of 180 meters calculate the acceleration.
8. A plane accelerates from 25 m/s to 55 m/s along the runway over a distance of 220 meters; calculate the acceleration.