

Find The Work WWW Done By The 18-newton Force. Use Two Significant Figures In Your Answer. Express Your

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Understanding the concept of work in physics is essential for analyzing how forces cause movement and transfer energy. When a force acts upon an object and causes displacement, work is done on that object. In this comprehensive guide, we will explore how to calculate the work done by an 18-newton force, emphasizing the importance of using two significant figures in the final answer. We will also review related concepts, formulas, and step-by-step examples to ensure clarity and practical understanding.

What Is Work in Physics?

Definition of Work

In physics, work is defined as the product of the force applied to an object and the displacement of the object in the direction of that force. Mathematically, it is expressed as:

- $W = F \times d \times \cos(\theta)$

where:

- **W** is the work done (measured in joules, J)
- **F** is the magnitude of the force applied (in newtons, N)
- **d** is the displacement of the object (in meters, m)
- **θ** is the angle between the force and the displacement vector

Key Points to Remember

- If the force is in the same direction as the displacement, $\theta = 0^\circ$, and $\cos(\theta) = 1$.
- If the force is perpendicular to the displacement, no work is done ($W = 0$).
- Work is a scalar quantity, meaning it has magnitude but no direction.

Calculating Work Done by an 18-Newton Force

Prerequisites for Calculation

To compute the work done, you need the following information:

1. The magnitude of the force applied (here, 18 N)
2. The displacement of the object (distance moved in meters)
3. The angle between the force and the displacement direction (if any)

Step-by-Step Calculation

Let's walk through the process with examples, assuming different scenarios:

Scenario 1: Force and Displacement in the Same Direction

Suppose an 18 N force causes an object to move 5 meters in the same direction as the force. Since the force and displacement are aligned, $\theta = 0^\circ$.

1. Identify the known values:
 - Force, $F = 18 \text{ N}$
 - Displacement, $d = 5 \text{ m}$
 - Angle, $\theta = 0^\circ$

2. Calculate $\cos(\theta)$:

$$\circ \cos(0^\circ) = 1$$

3. Compute work:

$$W = F \times d \times \cos(\theta) = 18 \text{ N} \times 5 \text{ m} \times 1 = 90 \text{ J}$$

Answer: The work done is 90 Joules.

Scenario 2: Force at an Angle to Displacement

Suppose the same force causes the object to move 5 meters at an angle of 60° relative to the force.

1. Known:

$$\circ F = 18 \text{ N}$$

$$\circ d = 5 \text{ m}$$

$$\circ \theta = 60^\circ$$

2. Calculate $\cos(\theta)$:

$$\circ \cos(60^\circ) = 0.50$$

3. Calculate work:

$$W = 18 \text{ N} \times 5 \text{ m} \times 0.50 = 45 \text{ J}$$

Answer: The work done is approximately 45 Joules (rounded to two significant figures).

Expressing Work with Two Significant Figures

Why Use Two Significant Figures?

In scientific calculations, significant figures reflect the precision of the measured data. When the force is given as 18 N, it has two significant figures, so the final answer should also be expressed with two significant figures for consistency and accuracy.

Applying Significant Figures in Calculations

- Round the final answer to two significant figures, considering the intermediate calculations.
- In the previous example, 90 J remains 90 J (since it already has two significant figures).
- For 45 J, it is already in two significant figures. If the calculation resulted in 44.6 J, it should be rounded to 45 J.

Additional Factors Affecting Work Calculation

Friction and Other Resistive Forces

In real-world scenarios, resistive forces such as friction can affect the work done. When friction is present, the net work done by the applied force considers the work done against resistive forces:

- $\text{Net work} = \text{Work done by applied force} - \text{Work done against resistive forces}$

Variable Forces and Non-Constant Displacement

If the force varies during the displacement, calculus methods like integration are used to compute work accurately.

Practical Applications of Work Calculation

Engineering and Mechanical Design

- Determining the energy required to move objects

- Designing efficient machines and systems

Physical Education and Sports Science

- Calculating energy expenditure during physical activities
- Assessing performance and efficiency

Summary and Key Takeaways

- Work is calculated as the product of force, displacement, and the cosine of the angle between them.
- Always use consistent units: force in newtons, displacement in meters.
- Express final answers with appropriate significant figures, especially when data is given with two significant figures.
- Understanding the direction of force relative to displacement is crucial for accurate work calculation.

Conclusion

Calculating the work done by an 18-newton force involves understanding the fundamental principles of physics and applying the correct mathematical formulas. Whether the force acts directly in the direction of motion or at an angle, the process remains systematic: identify known quantities, apply the work formula, and round the answer to two significant figures. Mastering these calculations enables better analysis of physical systems, informs engineering design, and enhances comprehension of energy transfer in various contexts.

Remember, the key to accurate work calculation is careful attention to units, angles, and significant figures. With practice, estimating the work done by forces becomes an intuitive and valuable skill for students, professionals, and enthusiasts alike.

Frequently Asked Questions

What is the work done by an 18-newton force if it moves an object 5 meters in the direction of the force?

The work done is 90 Joules.

How do you calculate the work done when a force of 18 N moves an object 10 meters?

Work done = Force $\times$ Distance = 18 N $\times$ 10 m = 180 Joules.

If an 18-newton force does 36 Joules of work, what is the distance moved?

Distance = Work / Force = 36 J / 18 N = 2 meters.

What is the work done by an 18 N force if the object is displaced 3 meters at an angle of 60° to the force?

Work done = Force $\times$ Distance $\times$ cos(θ) = 18 N $\times$ 3 m $\times$ cos(60°) = 18 $\times$ 3 $\times$ 0.50 = 27 Joules.

How much work is done by an 18 N force if it moves an object 7 meters perpendicular to the force?

Since the displacement is perpendicular, work done = 0 Joules.

A force of 18 N does 54 Joules of work. How far was the object moved?

Distance = Work / Force = 54 J / 18 N = 3 meters.

If a force of 18 N moves an object 8 meters, what is the work done?

Work done = 18 N $\times$ 8 m = 144 Joules.

What is the work done if an 18 N force moves an object 4 meters at an angle of 45° to the force?

Work done = 18 N $\times$ 4 m $\times$ cos(45°) $\approx$ 18 $\times$ 4 $\times$ 0.71 $\approx$ 51 Joules.

How do you determine the work done by an 18 N force over a displacement of 6 meters at an angle of 30°?

Work done = 18 N $\times$ 6 m $\times$ cos(30°) = 18 $\times$ 6 $\times$ 0.87 $\approx$ 94 Joules.

If a force of 18 N does 72 Joules of work, what is the displacement of the object?

Displacement = Work / Force = 72 J / 18 N = 4 meters.

Additional Resources

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Understanding Work in Physics: A Comprehensive Guide

In the realm of physics, the concept of work is fundamental to understanding how energy is transferred when a force acts upon an object. Whether it's pushing a box across the floor, lifting a weight, or pulling a sled, the work done quantifies the energy transferred during these actions. This article delves into the specifics of calculating work, focusing on a scenario involving an 18-newton force, and explores the various factors influencing the amount of work done. Our goal is to provide a clear, detailed explanation suitable for both students and enthusiasts keen on mastering the topic.

What is Work in Physics?

Before we analyze the specific problem involving the 18-newton force, it's essential to define what 'work' means in the context of physics.

Definition of Work

In physics, work is defined as the product of the force applied to an object and the displacement of that object in the direction of the force. Mathematically, it is expressed as:

$$W = F \times d \times \cos(\theta)$$

where:

- W is the work done (measured in Joules, J),
- F is the magnitude of the applied force (in Newtons, N),
- d is the displacement of the object (in meters, m),
- θ is the angle between the force vector and the displacement vector.

Key Points About Work

- Direction matters: Only the component of the force in the direction of displacement contributes to work.
- Positive and negative work: If the force component acts in the same direction as displacement, work is positive; if opposite, work is negative.

- Zero work: When no displacement occurs, or the force is perpendicular to the displacement, the work done is zero.

Scenario Setup: Calculating Work Done by an 18-Newton Force

Let's consider a practical example to contextualize the concept.

The Problem Statement

Suppose an object is pulled across a horizontal surface with a constant force of 18 N. The object moves a certain distance in the direction of the force. Your task is to calculate the work done by this force during the movement.

Assumptions for Calculation

To perform an accurate calculation, we need specific details:

- The magnitude of the force: 18 N (as given).
- The displacement: The distance over which the object is moved.
- The angle between the force and the displacement: For simplicity, assume the force acts in the direction of movement (i.e., $\theta = 0^\circ$).

If the problem does not specify the displacement, we can analyze the work done over a given distance or explore how the work varies with different displacements.

Calculating Work: Step-by-Step

Step 1: Identify the Variables

- Force, $F = 18 \text{ N}$
- Displacement, $d = [\text{Specify the distance; for example, 10 meters}]$
- Angle, $\theta = 0^\circ$ (assuming force is in the same direction as displacement)

Step 2: Convert Angle to Radians (if needed)

Since $\cos(\theta)$ is used, and θ is in degrees, it is often easier to work directly in degrees for cosines, as most calculators handle degrees directly.

- $\cos(0^\circ) = 1$

Step 3: Apply the Work Formula

Using the formula:

$$W = F \times d \times \cos(\theta)$$

Substituting the known values:

$$W = 18 \text{ N} \times d \times 1$$

For a displacement of, say, 10 meters:

$$W = 18 \text{ N} \times 10 \text{ m} = 180 \text{ Joules}$$

Step 4: Express the Answer with Two Significant Figures

The calculated work is 180 Joules. To express this with two significant figures:

$$W \approx 1.8 \times 10^2 \text{ Joules}$$

Impact of Displacement and Angle on Work

While the above calculation assumes perfect alignment, real-world scenarios often involve angles and varying distances. Let's explore how these factors influence the work done.

Varying Displacement

- Increasing the distance increases the work linearly, as work is directly proportional to displacement.
- For example, moving the same object 20 m with an 18 N force:

$$W = 18 \text{ N} \times 20 \text{ m} = 360 \text{ Joules}$$

Expressed in two significant figures:

$$W \approx 3.6 \times 10^2 \text{ Joules}$$

Varying the Angle

- If the force isn't aligned with displacement, only the component of the force in the direction of movement contributes.
- For a force at an angle θ :

$$W = F \times d \times \cos(\theta)$$

- For example, at $\theta = 60^\circ$:

$$\cos(60^\circ) = 0.5$$

- The work becomes:

$$W = 18 \text{ N} \times d \times 0.5$$

- For $d = 10 \text{ m}$:

$$W = 18 \text{ N} \times 10 \text{ m} \times 0.5 = 90 \text{ Joules}$$

Expressed with two significant figures:

$$W \approx 9.0 \times 10^1 \text{ Joules}$$

Real-World Applications and Considerations

Understanding how to calculate work is essential in various fields, from engineering to biomechanics.

Practical Applications

1. Lifting objects: Determining the energy required to lift a weight vertically.
2. Transportation: Calculating the work done by engines to move vehicles over distances.
3. Mechanical systems: Analyzing the efficiency of machines by calculating work input and output.

Factors Affecting Work in Practice

- Friction: Opposes the motion, reducing the net work done on the object.
- Variable forces: When force varies during movement, calculus is used to integrate the force over the displacement.
- Energy losses: In real systems, some energy is lost as heat, sound, etc.

Measuring Work in the Field

Physicists and engineers often use tools like dynamometers and motion sensors to measure force and displacement, enabling precise work calculations.

Advanced Considerations: Work Done in Non-Linear Scenarios

In more complex situations where forces change or motion isn't uniform, the calculation of work involves calculus.

Work as an Integral

If the force varies with position:

$$W = \int F(x) \, dx$$

This integral sums the infinitesimal work contributions over the path.

Example: Variable Force

Suppose force varies linearly with position:

$$F(x) = kx$$

The work done over a distance from 0 to d:

$$W = \int_0^d kx \, dx = (1/2) k d^2$$

This approach allows for precise calculations in complex systems, such as springs or variable resistance scenarios.

Summary: Key Takeaways

- Work quantifies the energy transferred when a force moves an object.
- The formula $W = F \times d \times \cos(\theta)$ captures the relationship, considering direction.
- In our example, with an 18 N force moving an object 10 meters in the same direction, the work done is approximately 180 Joules.
- Expressing the answer with two significant figures yields 1.8×10^2 Joules.
- Factors like angle, displacement, and external forces influence the total work.

Final Notes: Mastering the Concept

Understanding how force, displacement, and direction influence work is crucial for analyzing physical systems. Whether calculating the energy needed to lift an object, push a cart, or operate machinery, the principles outlined here provide a solid foundation. Remember, real-world situations often require considering additional factors like friction, variable forces, and energy losses, making the study of work a vital component of physics and engineering.

By grasping the fundamental formula and its applications, students and professionals alike can better analyze energy transfer processes across diverse scenarios, enhancing their problem-solving skills and understanding of the physical world.

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