How Much Work Is Done On A Small Car If A 3150 N Force Is Exerted To Move It 75.5 M To The Side Of The

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When analyzing physical scenarios involving forces and movement, understanding the concept of work is fundamental. In everyday life, we often push, pull, or move objects, sometimes without considering the energy involved. However, in physics, quantifying the work done on an object provides insight into the energy transfer during the process.

In this article, we will explore a specific situation involving a small car: if a force of 3150 Newtons is exerted to move it 75.5 meters to the side, how much work is done on the vehicle? We will break down the problem, explain the relevant physics principles, and perform detailed calculations to arrive at an accurate answer. Whether you're a student, educator, or enthusiast, this comprehensive guide will help clarify the concepts involved.

Understanding Work in Physics

Before diving into the specific problem, it's essential to understand what "work" means in the context of physics.

Definition of Work

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 can be expressed as:

$$W = F \times d \times \cos{\theta}$$

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

Conditions for Work to Be Done

Work is only done when:
- A force is applied to an object
- The object undergoes displacement
- There is a component of the force in the direction of displacement

In scenarios where the force is perpendicular to the displacement ($\theta = 90^\circ$), the work done is zero because $\cos 90^\circ = 0$.

Analyzing the Given Scenario

Let's analyze the specific problem:

> How much work is done on a small car if a force of 3150 N is exerted to move it 75.5 meters to the side of the vehicle?

At first glance, the problem seems straightforward, but several factors need to be clarified to calculate the work accurately.

Key Details and Assumptions

- Type of Force: The force is specified as 3150 N, but its direction relative to the displacement is crucial.
- Direction of Movement: The car is moved "to the side," implying lateral movement.
- Displacement Magnitude: The distance moved is 75.5 meters.
- Nature of the Force: Is the force applied parallel to the displacement, or at an angle?

In most real-world cases, lateral movement involves a force applied perpendicular to the initial orientation of the vehicle, such as pushing it sideways. If the force is purely perpendicular to the direction of displacement, no work is done, since the force does not contribute to moving the car forward or backward along the displacement.

Determining the Direction of the Force and Displacement

The key to calculating work is the angle between the force and displacement vectors.

Scenario 1: Force is Applied Directly Along the Direction of Displacement (Lateral Movement)

If the force is exerted horizontally, perpendicular to the initial orientation of the car, and the movement is also lateral in the same direction, then:

- $\theta = 0^\circ$
- $\cos 0^\circ = 1$

In this case, all the force contributes to the work done.

Scenario 2: Force is Applied Perpendicular to Displacement

If the force is perpendicular to the movement (e.g., pushing sideways without any component in the direction of movement), then:

- $\theta = 90^\circ$
- $\cos 90^\circ = 0$

and no work is done.

Calculating Work Done

Given these considerations, we'll analyze both scenarios.

Scenario 1: Force Aligned with Displacement

Using the work formula:

$$ W = F \times d \times \cos{\theta} $$

Since $\theta = 0^\circ$, $\cos 0^\circ = 1$:

$$ W = 3150\, \text{N} \times 75.5\, \text{m} \times 1 $$

$$ W = 3150 \times 75.5 $$

Calculating:

$$ W = 3150 \times 75.5 = 237,825\, \text{J} $$

Therefore, the work done is approximately 237,825 Joules.

Scenario 2: Force Perpendicular to Displacement

Since $\cos 90^\circ = 0$:

$$ W = 3150\, \text{N} \times 75.5\, \text{m} \times 0 = 0\, \text{J} $$

In this case, no work is done by the force in moving the car sideways.

Implications and Real-World Context

The amount of work done depends critically on the angle of application of the force relative to the displacement:

- If the force is applied in the same direction as movement (e.g., pulling or pushing along the path), the work is positive and equals the product of force and displacement.
- If the force is applied perpendicular to the movement (e.g., pushing sideways), no work is done in moving the car in that direction, as the force does not contribute to displacement along its line.

In the specific context of moving a vehicle sideways, practical situations often involve forces applied perpendicular to the direction of motion—such as pushing a car to a parking spot—resulting in zero work done in terms of energy transfer for lateral displacement because the force does not contribute to the movement in that direction.

However, if the force is applied at an angle less than 90°, the work can be calculated accordingly.

Additional Factors to Consider

While the simplified calculation provides the theoretical work done, real-world scenarios often involve additional complexities:

- Friction: Moving a car involves overcoming frictional forces, which require additional work.
- Internal Resistance: Mechanical inefficiencies and internal friction within the vehicle's components may influence the actual energy expenditure.
- Type of Force: If the force is exerted via a mechanical device (e.g., a tow truck), the efficiency of the system impacts the actual work done.

In this analysis, we assume ideal conditions, where the force applied is the only factor, and no energy losses occur.

Summary and Key Takeaways

- Work is the energy transferred when a force causes displacement in the direction of the force.
- The formula for work: $W = F \times d \times \cos{\theta}$
- In the case of moving a small car sideways with a force of 3150 N over 75.5 meters:
- If the force is aligned with the movement, work done is approximately 237,825 Joules.
- If the force is perpendicular, no work is done in moving the car sideways.
- The actual energy expenditure depends on the force's direction relative to displacement.

Conclusion

Understanding how much work is done when exerting a force on a small car provides insight into energy transfer in physical systems. The calculations demonstrate the importance of force direction, displacement, and angle in determining work done. Whether moving a vehicle sideways in a parking lot or analyzing forces in a physics class, these principles form the foundation for understanding energy and motion.

By carefully considering the force's orientation and the displacement, you can accurately assess the work involved in various physical tasks. Remember, in real-world applications, factors like friction and mechanical efficiency also influence the total energy expenditure, but the fundamental physics principles remain the same.

References:

- Halliday, Resnick, and Walker, Fundamentals of Physics, 10th Edition.
- Serway and Jewett, Physics for Scientists and Engineers.
- Khan Academy, Work and Energy tutorials.

Keywords: work, force, displacement, physics, small car, lateral movement, energy transfer, Newtons, Joules, angle of force

Frequently Asked Questions

What is the formula to calculate work done when a force moves an object a certain distance?

Work done (W) is calculated as the product of the applied force (F) and the displacement (d) in the direction of the force: W = F × d.

How much work is done when a 3150 N force moves a small car 75.5 meters sideways?

The work done is W = 3150 N × 75.5 m = 237,825 Joules.

Does the direction of force affect the amount of work done in this scenario?

Yes, work is only done when the force has a component in the direction of the displacement. If the force is purely sideways and perpendicular to the direction of movement, no work is done in the direction of displacement.

What assumptions are made when calculating work in this problem?

It is assumed that the force exerted is in the direction of displacement, and that there are no other forces (like friction or resistance) doing work or opposing the movement.

How does the magnitude of the force influence the work done on the car?

The greater the force applied in the direction of movement, the more work is done. Work is directly proportional to both force and displacement.

Can the work done be negative in this context?

Work can be negative if the force opposes the displacement (e.g., friction). In this case, since the force is exerted to move the car sideways, the sign depends on the force's direction relative to movement.

What real-world factors could affect the actual work done when moving a car sideways?

Factors such as friction, resistance from the surface, and any additional forces like air resistance can reduce the net work done or require additional force, affecting the total work calculation.

Additional Resources

Work Done Calculation on a Small Car: A Detailed Analysis of a 3150 N Force Moving it 75.5 M

When examining the mechanics of force and motion, understanding how much work is performed on an object is fundamental. In this article, we delve into the specifics of calculating the work done on a small car when a force of 3150 N is exerted to move it horizontally by 75.5 meters. Whether you're a student, engineer, or automobile enthusiast, this comprehensive review aims to clarify the concepts and calculations involved, providing a clear picture of the work-energy relationship in practical scenarios.

Understanding Work in Physics

Before diving into the calculation, it's essential to grasp what "work" entails within the realm of physics.

Definition of Work

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

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

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

Key Point: If the force is applied in the same direction as the displacement, $\theta = 0^\circ$, and $\cos 0^\circ = 1$, simplifying the work calculation.

Scenario Overview: Moving a Small Car

Let's contextualize the problem:

- Force exerted: 3150 N
- Displacement: 75.5 meters
- Direction of force and displacement: Assumed to be along the same line (horizontal movement)

In real-world applications, forces might not always align perfectly with displacement, but for simplicity and typical case analysis, we assume a direct, aligned force.

Calculating the Work Done

Step 1: Confirm the Directionality

Given the force and displacement are in the same direction, the angle $\theta = 0^\circ$, which simplifies calculations as:

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

Step 2: Apply the Work Formula

Using the basic work formula:

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

Substituting the known values:

$$ W = 3150\, \text{N} \times 75.5\, \text{m} \times 1 $$

$$ W = 3150 \times 75.5 $$

Calculating:

$$ W = 3150 \times 75.5 $$
$$ W = (3000 + 150) \times 75.5 $$
$$ W = 3000 \times 75.5 + 150 \times 75.5 $$
$$ W = 226,500 + 11,325 $$
$$ W = 237,825\, \text{J} $$

Result: The work done on the small car is 237,825 Joules.

Interpreting the Results: What Does 237,825 Joules Mean?

This quantity of energy, approximately 238 kilojoules, reflects the amount of mechanical work required to move the car over that distance against resistive forces such as friction and air resistance (assuming these resistances are either negligible or included in the effective force). It is a measure of the energy transferred to the car's motion.

Contextual Breakdown:

- Energy input: The exerted force and the resulting work directly relate to the energy supplied to overcome static and kinetic friction.
- Efficiency considerations: In real-world scenarios, some energy is lost as heat due to frictional forces; thus, the actual energy required might be higher.
- Implication for vehicle design: Understanding the work involved aids in designing engines, brakes, and drivetrain components to optimize energy consumption.

Additional Factors to Consider

While the straightforward calculation provides an initial understanding, several additional factors influence the real work scenario:

1. Frictional Forces

- The force required to move the car includes overcoming static and kinetic friction.
- The coefficient of friction between the tires and road surface critically affects the total force needed.
- If the 3150 N is the total force exerted including overcoming friction, then the work calculation remains valid as is.

2. Inclined Surfaces

- If the movement involved any incline, the component of gravitational force would need to be considered.
- For purely horizontal motion, this factor is negligible.

3. Resistance and Drag

- Air resistance (drag) adds to the force needed, especially at higher speeds.
- The calculated work would need adjustment if these forces are significant.

4. Energy Losses

- Mechanical inefficiencies, such as rolling resistance and transmission losses, mean actual energy expenditure is higher than the ideal calculation.

Practical Applications and Broader Implications

Understanding the work done in moving vehicles is critical in various industries and research areas:

- Automobile Engineering: Optimizing engine power and fuel efficiency relies on quantifying the work done to move vehicles.
- Transportation Planning: Estimating energy requirements for fleet operations.
- Physics Education: Demonstrating real-world applications of work and energy principles.
- Renewable Energy: Designing systems that minimize energy expenditure in vehicle propulsion.

In essence, calculating work provides insights into energy consumption, efficiency, and mechanical design considerations.

Summary: Key Takeaways

- The work done on a small car when a 3150 N force moves it 75.5 meters in the same direction is approximately 237,825 Joules.
- This calculation assumes ideal conditions with force and displacement aligned and neglects additional resistive forces.
- Real-world scenarios often involve additional complexities such as friction, air resistance, and mechanical inefficiencies, which can increase the actual energy required.
- Understanding these principles is essential for engineers, physicists, and transportation planners aiming to optimize energy use and vehicle performance.

Final Thoughts

The quantified work offers a window into the energy dynamics of moving a small vehicle—a task that, while seemingly straightforward, encompasses complex interactions of forces, resistances, and efficiencies. Whether for academic purposes or practical engineering, mastering such calculations deepens our comprehension of physical laws governing everyday phenomena and technological systems.

By appreciating the nuances behind the simple formula, professionals and enthusiasts alike can better analyze, design, and optimize systems that move through our world with efficiency and precision.

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