A Student Did 24 J Of Work On A Chair. She Applied A Force Of 12 N And Moved The Chair 2 M. What Else

A Student Did 24 J Of Work On A Chair. She Applied A Force Of 12 N And Moved The Chair 2 M. What Else

Understanding the fundamental concepts of work, force, and displacement is essential in physics, especially when analyzing everyday activities such as moving furniture. In this article, we delve into the scenario where a student applies a force to move a chair, performing a certain amount of work. We'll explore the physics behind the problem, dissect the calculation steps, and expand on related concepts such as work, energy, and power, providing a comprehensive understanding suitable for students and enthusiasts alike.

Basics of Work in Physics

Before analyzing the specific problem, it's important to revisit the fundamental concept of work in physics.

What Is 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:

- **Work (W) = Force (F) × Displacement (d) × cosθ**

where:
- F is the magnitude of the force applied,
- d is the displacement of the object,
- θ is the angle between the force and displacement vectors.

Key Points:
- Work is scalar quantity.
- Work is positive when the force and displacement are in the same direction.
- No work is done if the force is perpendicular to the displacement (e.g., lifting an object directly upward when moving it horizontally).

Analyzing the Given Scenario

Let's revisit the specific problem:

- The student performs 24 Joules of work.
- The force applied is 12 Newtons.
- The displacement of the chair is 2 meters.

Using this information, we can analyze and verify the calculations, understand what other quantities can be derived, and explore related physics concepts.

Calculating Work Done

Given:
- Work done, $W = 24$ J
- Force applied, $F = 12$ N
- Displacement, $d = 2$ m

Since work is calculated as:

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

Assuming the force was applied in the direction of the displacement (which is typical unless otherwise specified), then $\theta = 0°$, and $\cos\theta = 1$.

Thus,

$$W = F \times d$$

$$24 \text{ J} = 12 \text{ N} \times 2 \text{ m}$$

which confirms the calculation:

$$12 \text{ N} \times 2 \text{ m} = 24 \text{ J}$$

This matches the work done, confirming the assumptions.

What Else Can Be Derived From This Scenario?

Beyond the basic calculation, several other physical quantities and concepts can be explored:

1. The Angle of Application of Force

If the force was not applied perfectly in the direction of motion, the angle θ would be different, affecting the work calculation.

- Work formula: $W = F \times d \times \cos\theta$
- Rearranged: $\cos\theta = W / (F \times d)$

Given the values:

$\cos\theta = 24 \text{ J} / (12 \text{ N} \times 2 \text{ m}) = 24 / 24 = 1$

This confirms that the force was applied in the same direction as the displacement.

Implication: The student applied force directly in the direction of the chair's movement.

2. The Work-Energy Theorem

This fundamental principle states:

- Work done on an object is equal to the change in its kinetic energy.

In this case, since the chair was moved 2 meters with a certain applied work, the energy transferred could be used to:

- Overcome resistive forces such as friction.
- Impart kinetic energy to the chair if it was initially at rest.

Note: If the chair initially was at rest and experienced no other forces, then the work done would translate into its kinetic energy.

3. Friction and Real-World Considerations

In practical scenarios, moving a chair involves overcoming friction between the chair's legs and the floor.

- Frictional Force (F_f): A resistive force opposing motion.
- The work done against friction can be calculated if the coefficient of friction (μ) and normal force (which equals weight if on a horizontal surface) are known.

Suppose:
- The mass of the chair, m.
- The acceleration due to gravity, $g = 9.8\ m/s^2$.

The normal force:

$$N = m \times g$$

Frictional force:

$$F_f = \mu \times N$$

If the student's applied force was 12 N, and the work done was 24 J, then:

- The net work considers overcoming both friction and imparting kinetic energy.
- Additional information about the mass of the chair or the coefficient of friction would be needed for detailed calculations.

Related Concepts in Physics

To fully understand the scenario, it's important to consider other physics principles associated with work and force.

Work Done in Different Directions

- When force is applied at an angle, the component of force in the direction of displacement is $F \times \cos\theta$.
- For example, if force is applied at an angle, the effective work reduces, and some energy goes into other forms (e.g., lifting the chair slightly).

Power and Rate of Doing Work

- Power (P) is the rate at which work is done:

$P = W / t$

- If the time taken to move the chair is known, the student can compute the power exerted.

Energy Conservation

- The work done on the chair is stored as kinetic energy or as potential energy if lifted.
- If no other forces (like friction or air resistance) are involved, the energy transfer is straightforward.

Practical Application and Educational Importance

Understanding such problems is vital for students studying physics as it bridges theoretical concepts with real-life activities. It emphasizes:

- The importance of measuring force, displacement, and work.
- How to analyze force vectors and angles.
- The relevance of energy transfer in everyday tasks.

Sample Problems for Practice

To reinforce learning, here are some related exercises:

1. If the student applied a force of 15 N and moved the chair 3 meters, how much work was done?

2. Calculate the work done if the force was applied at an angle of 30° to the horizontal and the displacement was 2 meters with a force of 12 N.

3. Assuming the chair has a mass of 10 kg, what is its kinetic energy after being moved 2 meters with the given work?

Answers:

1. Work = 15 N × 3 m = 45 J
2. Work = $F \times d \times \cos\theta$ = 12 N × 2 m × cos30° ≈ 12 × 2 × 0.866 ≈ 20.78 J
3. Kinetic energy = Work done (assuming all work converts into kinetic energy) = 24 J

Conclusion

The scenario where a student performs 24 Joules of work by applying a 12 N force over 2 meters on a chair illustrates key physics principles regarding work, force, and energy transfer. Analyzing this problem helps deepen understanding of how forces produce movement and how energy is conserved and transformed in real-world activities. Whether in academic examinations or practical tasks, grasping these concepts enhances problem-solving skills and provides insight into everyday physics phenomena.

Remember:
- Always consider the direction of forces.
- Recognize the role of resistive forces like friction.
- Use the basic formulas accurately to analyze similar problems.

By mastering these concepts, students can confidently approach a wide range of physics problems involving work and energy.

Frequently Asked Questions

How is work calculated in this scenario?

Work is calculated by multiplying the force applied by the distance moved in the direction of the force, so Work = Force × Distance.

What is the work done by the student on the chair?

The student did 24 Joules of work on the chair, as given in the problem statement.

Given the force and distance, how can we verify the work done?

Work = Force × Distance = 12 N × 2 m = 24 Joules, which matches the given work done.

Why does the calculated work match the given work done?

Because work is directly proportional to force and displacement; the values provided are consistent with the work done on the chair.

If the work done was different, what factors could affect it?

Factors include the magnitude of force applied, the distance moved, the angle of force application, and any opposing forces like friction or resistance.

What is the significance of knowing the work done in physics problems?

It helps in understanding energy transfer, efficiency of work, and the amount of energy required to perform a task.

Can the work done be negative in this context?

Yes, if the force applied opposes the direction of movement, the work done would be negative, indicating work done against the motion.

Additional Resources

A Student Did 24 J Of Work On A Chair. She Applied A Force Of 12 N And Moved The Chair 2 M. What Else?

This scenario presents an interesting opportunity to explore the fundamental concepts of work, force, and displacement in physics. When a student states that she did 24 J of work on a chair, and we learn that she applied a force of 12 N to move it 2 meters, it invites a deeper analysis of the principles involved, potential calculations, and related concepts such as energy transfer, efficiency, and the nature of work in mechanics. Let's break down this situation comprehensively.

Understanding the Basics: What is Work in Physics?

Before delving into calculations, it's crucial to understand what work means in a physics context.

Work (W) is defined as the product of the force (F) applied to an object and the displacement (d) of that object in the direction of the force. Mathematically:

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

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 displacement vectors.

Key points:
- If the force is applied in the same direction as displacement, $\cos(\theta) = 1$, and the work simplifies to $W = F \times d$.
- If the force is perpendicular to the displacement, $\cos(\theta) = 0$, and no work is done.

- The sign of work indicates whether energy is transferred to or from the object—positive work adds energy, negative reduces energy.

Analyzing the Given Data

From the scenario:

- Work done (W): 24 J
- Force applied (F): 12 N
- Displacement (d): 2 m

Using these, we can verify the validity of the data and explore what else might be involved.

Step 1: Confirm the Direction of Force

Assuming the force is applied in the same direction as the movement (which is typical unless specified otherwise), then:

$\cos(\theta) = 1$

Thus, the work done simplifies to:

$W = F \times d$

Plugging in the numbers:

$W = 12\text{ N} \times 2\text{ m} = 24\text{ J}$

This matches the given work, confirming that the force was applied in the same direction as the displacement.

Conclusion: The data is consistent with the force being applied in the same direction as the chair's movement.

Step 2: Exploring Additional Aspects of the Scenario

Having confirmed the basic calculations, let's explore what additional insights or questions arise from this situation.

a) Is the force purely applied in the horizontal direction?

If the force was not purely horizontal, the actual component of the force contributing to the work would be:

$F_{horizontal} = F \times \cos(\theta)$

Given that the work is 24 J, and F is 12 N, then:

$W = F_{horizontal} \times d$

which gives:

$24\ J = F \times \cos(\theta) \times 2\ m$

or

$F \times \cos(\theta) = 12\ N$

Since $F = 12\ N$:

$12\ N \times \cos(\theta) = 12\ N$

$\Rightarrow \cos(\theta) = 1$

$\Rightarrow \theta = 0°$

Implication: The applied force is aligned with the direction of movement, confirming our earlier assumption.

b) What about other forces acting on the chair?

In real-life scenarios, various forces oppose or assist movement.

- Friction: The primary opposing force when moving a chair across a surface.
- Gravity: Acts vertically downward; irrelevant to horizontal work unless lifting.
- Normal force: Acts upward; does no work unless there's vertical displacement.

Given the work done is 24 J, the student must have exerted enough force to overcome friction and move the chair.

Step 3: Calculating the Force of Friction

Suppose the force applied by the student is just enough to overcome static or kinetic friction, then:

F_friction = F_applied - F_component

Given the force applied is 12 N, and assuming it was just enough to move the chair at constant velocity (implying net force is zero), then:

F_friction = 12 N

This suggests the kinetic friction force is approximately 12 N. However, to confirm this, we need to understand the coefficient of kinetic friction.

a) Coefficient of Kinetic Friction (μ_k)

The friction force is given by:

F_friction = μ_k × N

Where:
- μ_k is the coefficient of kinetic friction,
- N is the normal force, which on a flat surface equals the weight of the chair (mass × gravity).

Assuming the chair's weight is known or can be estimated:

Suppose, for example, the chair's weight is 50 N (which corresponds to a mass of approximately 5.1 kg under gravity 9.8 m/s^2). Then:

μ_k = F_friction / N = 12 N / 50 N = 0.24

This coefficient indicates moderate friction typical for wooden or plastic chairs on common flooring.

Step 4: Energy Considerations

Beyond just work and force, it’s valuable to think about energy transfer.

a) Kinetic Energy Gained

The work done on the chair is converted into kinetic energy if the chair accelerates:

$KE = (1/2)\ m\ v^2$

If the chair started from rest and moved 2 meters with constant velocity, then:

- No net work is done to accelerate it, or
- The work done is just enough to compensate for friction and any other resistive forces, maintaining constant velocity.

b) Energy lost to friction

The work done to overcome friction is:

$W_{friction} = F_{friction} \times d = 12\ N \times 2\ m = 24\ J$

This energy is dissipated as heat due to friction.

c) What about the energy input?

Since the work done is 24 J, and assuming no other energy losses, the student's effort transferred energy into overcoming friction and possibly imparting some kinetic energy if the chair accelerates.

Step 5: What Else Can Be Derived or Considered?

This scenario opens up several avenues for further exploration.

1. Calculating the Work Done in Different Conditions

- If the force was applied at an angle (say, 30° above the horizontal), how would the work change?

- $F_{horizontal} = F \times \cos(30°) \approx 12\ N \times 0.866 \approx 10.39\ N$
- $Work = F_{horizontal} \times d \approx 10.39\ N \times 2\ m \approx 20.78\ J$

The work would be less because part of the force would be vertical, doing no work in moving the chair horizontally.

2. Estimating the Student's Effort

- How much force does a student need to exert to move the chair? If the coefficient of friction is known, the minimum force is equal to the friction force.

3. Efficiency of the Work

- The efficiency can be thought of as the ratio of useful work (moving the chair) to the total effort exerted, considering energy losses like heat.

4. Time and Power

- If the student moved the chair in a certain duration, say 4 seconds, then:

- Power = Work / Time = 24 J / 4 s = 6 W

- Power indicates the rate at which work was done, which ties into muscle effort and energy expenditure.

Conclusion: What Else?

Beyond the straightforward calculation of work, force, and displacement, this scenario helps illuminate several core physics principles:

- The relationship between force, displacement, and work.
- The importance of directionality and angles in work calculations.
- The role of friction as an opposing force and energy dissipation.
- How to estimate or calculate coefficients of friction based on applied forces.
- The connection between work, energy transfer, and power.
- Real-world applications like understanding the effort involved in moving objects and the efficiency of such tasks.

In essence, this simple scenario serves as an excellent example to understand the fundamentals of mechanics and energy transfer, reinforcing core concepts that are applicable across various fields—from engineering and physics to everyday life activities like moving furniture or designing efficient transportation systems.

Final note: When analyzing real-world problems, always consider all forces involved, the directions of forces, and energy conservation principles to develop a comprehensive understanding.

A Student Did 24 J Of Work On A Chair She Applied A Force Of 12 N And Moved The Chair 2 M What Else

A Student Did 24 J Of Work On A Chair She Applied A Force Of 12 N And Moved The Chair 2 M

What Else

Related Articles

- A Hiker Collected Several Rocks Along Her Trek Through The Forest For Her Geology Project. She Needed
- A Traffic Light Hangs From A Pole As Shown In (Figure 1). The Uniform Aluminum Pole AB Is 7.60 M Long
- A Particularly Dangerous Type Of Drug Resistance Is Mediated By . In Which A Single Mechanism In This

Back to Home