WORK & ENERGY DAY 1

UNIT PREVIEW

Last year, you learned the mantra: energy comes in many forms, changes shape, and is always conserved. This year, we make that concept **calculable**.

We begin with the mechanism of energy transfer: **work**—energy transferred to an object when an external force moves it in the direction of the force.

This precise definition (which is not the same as feeling tired) unlocks kinetic energy, potential energy, conservation laws, and power. Over the next ten days, we'll build this framework carefully. *Most students find it easier than Newton's Laws and kinematics!*

⏱ **Warm-Up (3 min)** — Rate the **physical effort** required (1 = easy, 10 = exhausting):

A. Hold a 20 kg suitcase still for 60 s. ___

B. Carry it 50 m across a flat floor. ___

C. Push hard on a brick wall for 30 s. ___

D. Lift it from the floor to overhead. ___

Prediction: Rank A–D by *physics work done on the suitcase*. ___ > ___ > ___ > ___

THE SURPRISE

Physics says **three** of those tasks involve *zero* work on the suitcase. Only **one** counts.

Key idea: Work is defined from the object's perspective. You may feel tired, but unless a force moves the object *in the direction of that force*, no work is done on it.

On language: We define Work first. When you hear "energy," think **stored work** for now.

WHAT COUNTS AS WORK?

Work happens only when **both** conditions are met:

1. A force acts on the object.
2. The object displaces in the direction of that force (at least partially).

WE DO **Revisit the Warm-Up**

Task	Force direction?	Displacement?	Work on suitcase?
A (hold)			
B (carry)			
C (wall)			
D (lift)			

THE EQUATION

WORK

$$W = Fd\cos\theta$$

F = magnitude of force (N)
d = displacement (m)

θ = angle between $\vec{F}$ and $\vec{d}$
W = work (J = N·m)

The Joule: Work is measured in joules (J), named for James Prescott Joule. One joule is roughly the energy needed to lift an apple one meter.

THREE CASES

$\theta = 0^\circ$	$\theta = 180^\circ$
Force WITH motion	Force AGAINST motion
$\cos 0^\circ = 1$	$\cos 180^\circ = -1$
Positive Work	**Negative Work**

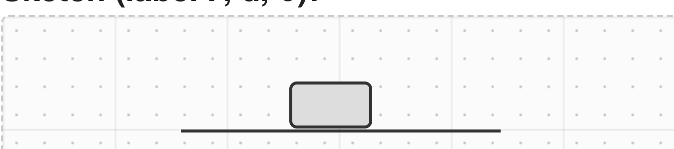
(θ = 90°) → Force ⊥ to motion → (cos 90° = 0) → **Zero Work**

The Zero-Work Trap: A force can exist and an object can move, but if they're perpendicular, no work is done.

WE DO **Pulling a Sled**

You pull a sled with 60 N at 25° above horizontal. It moves 8 m.

Sketch (label F, d, θ):



Calculate the work done by the pulling force:

Use $W = Fd\cos\theta$.

YOU DO **Pushing a Mower**

You push a mower with 80 N at 35° below horizontal. It moves 12 m.

Find the work done by *your* force.

READING THE SIGN OF WORK

Before calculating, predict: will the work be **positive**, **negative**, or **zero**?

SKILL **Sign Prediction**

Scenario	Sign of Work	Why?
Friction on a sliding box		
Normal force on that same box		
Gravity on a ball falling down		
Gravity on a ball thrown up (while rising)		

QUICK **Friction Does Negative Work**

A box slides **4.0 m** to the right while kinetic friction of magnitude **6.0 N** acts to the left.

a. Is the work done by friction **positive**, **negative**, or **zero**? ________

b. Calculate the work done by friction. (Hint: $\theta = 180^\circ$.)

KEY IDEA **Path Independence**

Two identical balls start at the same height. Ball A drops straight down. Ball B slides down a frictionless ramp.

Sketch both paths. Label the height h:

Which ball has more work done on it by gravity?

☐ Ball A ☐ Ball B ☐ Same

Explain using $W = Fd\cos\theta$:

The takeaway: Gravity's work depends only on **vertical displacement**, not the path taken. This will matter when we define gravitational potential energy.

HOMEWORK

1 True or False

Correct any false statements.

______ If you push on an object and it doesn't move, you've done no work on it.

______ Carrying a heavy box across a room requires positive work on the box.

______ Work can be negative.

2 Lifting vs. Carrying

A 15 kg box is lifted 2 m, then carried horizontally 10 m.

(a) Work done by lifting force? (b) Work done by lifting force while carrying?

3 Pushing Up a Ramp

A 10 kg block is pushed at constant speed up a frictionless ramp. The ramp is 5.0 m long, inclined at 30° above horizontal (so the top is 2.5 m high).

Find the work done by the pushing force on the block.

4 Orbital Motion

The Moon orbits Earth in a nearly circular path. Gravity pulls the Moon toward Earth at all times.

How much work does gravity do on the Moon in one complete orbit? *Hint: Think about θ between force and velocity.*