WORK & ENERGY DAY 4: KINETIC ENERGY

Part 2 of 2 — Testing whether stored work becomes motion

⏱ **Warm-Up: Recall Yesterday** — Pull out your Day 3 packet. Write your values:

k = _____ N/m   x = _____ m   W = _____ J   v ≈ _____ m/s

Today's question: Does stored work become motion? We need a formula for "motion energy."

THE "MOTION ENERGY" FORMULA

KINETIC ENERGY (K)

$$K = \tfrac{1}{2}mv^2$$

m = mass (kg),   **v** = speed (m/s),   **K** = Kinetic Energy (J).   Scalar, always ≥ 0.

DERIVATION   **Build $W_{net} = \Delta K$ from $F = ma$ and kinematics**

Constant net force F_{net} acts on mass m over distance d, changing speed from v_i to v_f.

1) Work: $W_{net} = F_{net} \cdot d$.   **2)** Sub $F = ma$: $W_{net} = ($ _____ $) \cdot d$

3) From $v_f^2 = v_i^2 + 2ad$, isolate: $ad = $ _____

4) Combine: $W_{net} = m(ad) = m\,($ _____ $)$

5) Distribute: $W_{net} = $ ____$mv_f^2 \; - \;$ ____mv_i^2

Definition: $K \equiv \tfrac{1}{2}mv^2$.   Then: $W_{net} = \Delta K = K_f - K_i$.

Checkpoint: If W_{net} is negative, what happens to K (and speed)? _____

THE WORK-ENERGY THEOREM

$$W_{net} = \Delta K = K_f - K_i \quad — \quad \text{Net work = change in kinetic energy.}$$

THE MOMENT OF TRUTH

Yesterday you found the spring stores $W = \frac{1}{2}kx^2$ J. **Claim:** if that stored work all becomes KE:

$$\frac{1}{2}kx^2 = \frac{1}{2}mv^2 \quad \rightarrow \quad v = \sqrt{\frac{k}{m}}\, x$$

PREDICT **Calculate Expected Speed**

Using your k and the cart mass, predict the launch speed.

k = _____ N/m   x = _____ m

m = _____ kg

Calculate $v = \sqrt{\frac{k}{m}}\, x$:

Predicted v: _____ m/s

DATA **Measure Actual Speed**

Trial	Stretch x (m)	Measured v (m/s)	Predicted v (m/s)
1			
2 (double x)			

Percent difference: _____

ANALYZE **The v² Test**

Doubling stretch → **4x** stored energy ($W \propto x^2$). If all becomes KE ($K \propto v^2$), speed should increase by factor _____.

From data: $v_2/v_1 =$ _____ Close to 2? **If ratio < 2, where did the "missing" energy go?**

_____

Verdict: Does stored spring work become KE? _____.   Predicted vs. actual agree to within _____%.

PRACTICE: USING THE WORK-ENERGY THEOREM

We now have a powerful tool: **net work causes changes in kinetic energy.**

WE DO   **Stopping Distance**

A car traveling at speed v skids to a stop in distance d.

If the car were traveling at **2v**, how far would it slide before stopping? (Assume same friction force.)

Reasoning steps:

1. Doubling speed $\rightarrow$ _____ times the kinetic energy.
2. Friction removes energy by work: $W = Fd$.
3. To remove $4\times$ energy with the same force, you need _____ times the distance.

Answer:

_____ **d**

YOU DO   **Calculations**

1. A 1000 kg car accelerates from 0 to 20 m/s. Calculate the net work done on the car.

2. The same car accelerates from 20 m/s to 40 m/s. Calculate the net work done.

3. Why does it take so much more work to gain the second 20 m/s?

Pro Tip: ΔK depends on $v_f^2 - v_i^2$, not $(v_f - v_i)^2$.

Going from 0→20 changes v^2 by 400. Going from 20→40 changes v^2 by 1200!

1 **Arrow Comparison**

Two identical arrows: A at speed v, B at speed $3v$. (a) Which has more KE? (b) How many times more?

2 **Sign of Work**

A ball is thrown straight up. While rising:

(a) Is gravity doing positive or negative work? _____ (b) Is KE increasing or decreasing? _____

(c) Do your answers match $W_{net} = \Delta K$? Explain.

3 **Bullet vs. Gun**

A gun fires a bullet. Force on bullet = force on gun (Newton's 3rd), but the bullet travels far down the barrel while the gun barely recoils. Which gains more KE? Use $W = Fd$ to explain.

4 **Hammer Time**

You swing a hammer (mass m) at a nail at speed v. It drives the nail distance d into wood. Write an expression for the **average force** F on the nail. (Hint: nail does negative work on hammer.)