

LEVERS



Simply The Way Things Work – Mechanics & Movement

Name: _____ Date: _____

Word Bank: First, Effort, Second, Fulcrum, Third, Lever

The Three Main Parts

1. A _____ is a simple machine made of a rigid bar that turns around a fixed point to help us move heavy objects with less effort.
2. The _____ is the magic pivot point that stays perfectly still while the lever turns around it.
3. The _____ is the input force or the muscle power you apply to the lever to make it move.

The Three Classes of Levers

1. In a _____-class lever, the fulcrum is right in the middle (like a seesaw or your dirt bike's front brake handle!).
2. In a _____-class lever, the heavy load is in the middle, making it easy to lift massive weights (like a wheelbarrow or a dirt bike stand!).
3. In a _____-class lever, your muscle effort is applied in the middle, which helps move things fast over a long distance (like a hockey stick or your leg kicking the starter!).

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week 2: Mechanical Advantage and the Power of Strategy

Daily Scripture Focus

"If the ax is dull and its edge unsharpened, more strength is needed, but skill will bring success." — Ecclesiastes 10:10

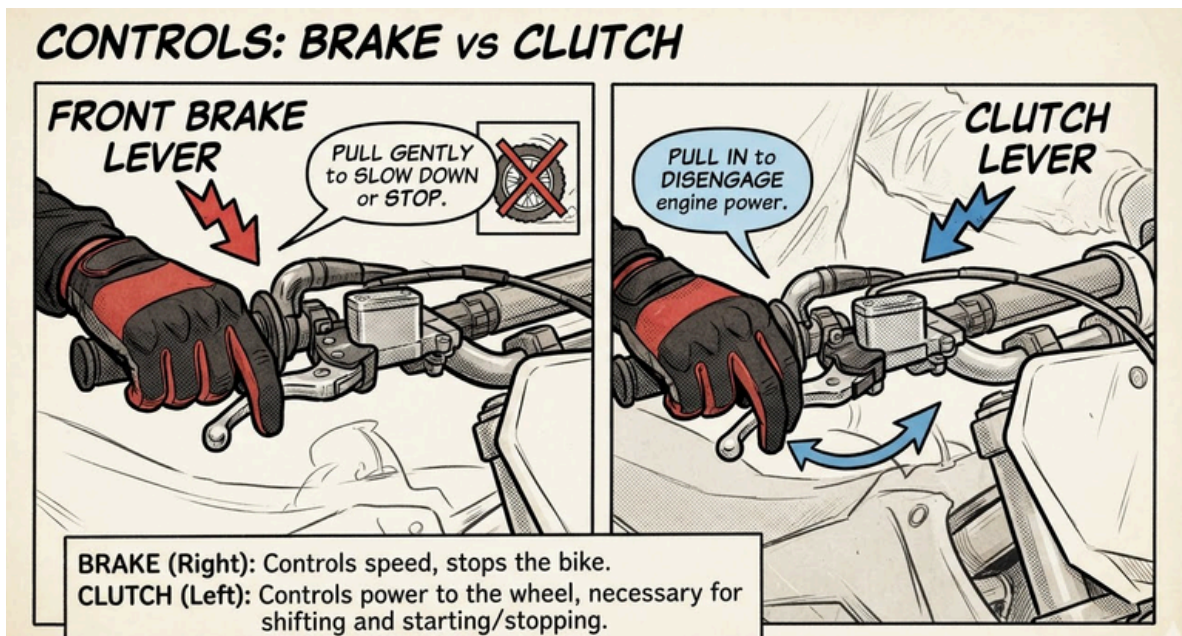
Working smarter is always better than just working harder. Engineers use simple machines as tools to get the most impact of their efforts.

The Engineering Science

A lever is perfectly balanced when the work you put into it matches the work that comes out. But here is the coolest part: levers allow you to trade distance for force. Engineers call this awesome trade-off **Mechanical Advantage!**

Think about your front brake handle again. When you squeeze the very tip of the handle, your fingers pull it a long distance. Inside the brake system, a tiny metal plunger moves only a tiny fraction of an inch—but it moves with giant, super-strong force!

You are trading a long, easy squeeze with your fingers for a short, incredibly powerful push that squeezes the brakes tight to stop your bike!



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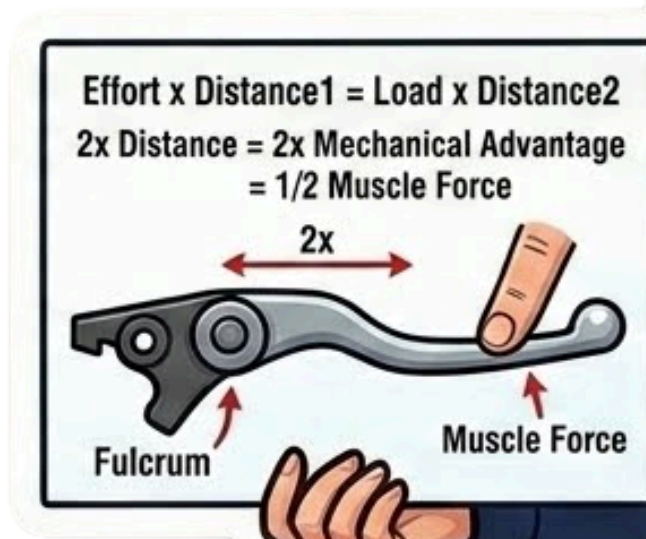
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week 2: Mechanical Advantage and the Power of Strategy

The Engineering Science

The math secret of a lever is all about balance! To make a lever perfectly balanced, you take the pushing force (your effort) and multiply it by how far away you are from the pivot point (the fulcrum). That final number must exactly equal the weight of the heavy object (the load) multiplied by its distance from the pivot point. If both sides match, the lever stays perfectly still—but if your side is stronger, you can lift almost anything!

Think of it like a trick for your muscles! If you move your fingers twice as far away from the pivot bolt on your brake handle, you double your pulling power. Because the handle does twice as much work for you, your hands only have to use half as much muscle strength to squeeze the brakes and stop the bike.



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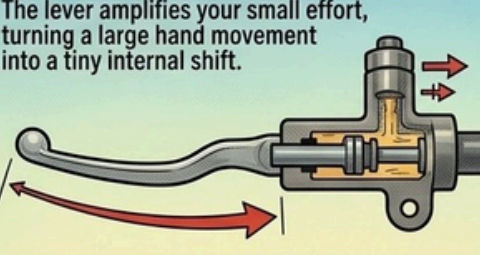
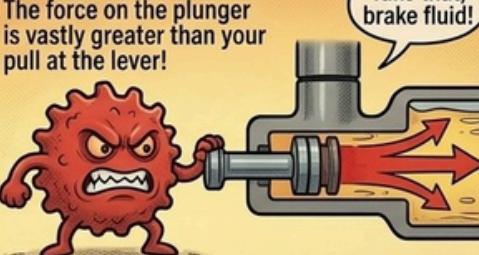
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week 2: Mechanical Advantage and the Power of Strategy

In dirt bike dynamics, Ecclesiastes 10:10 describes the exact difference between a poorly maintained, poorly understood machine and an engineered system using mechanical advantage. Trying to ride a dirt bike with a dull, unsharpened setup forces the rider's body to work harder with exhausting, labor.

This is where smart engineering comes in! Instead of just working harder and tiring out your muscles, dirt bike designers build simple machines right into the motorcycle. By using mechanical wisdom instead of raw strength, you can ride faster, conquer tough trails, and win the race by riding smarter!

Imagine a dirt bike as a super-team of simple tools like wheels, ramps, and levers all working together! These built-in tools do the heavy lifting for you, giving your muscles superpower strength. They help the bike zoom over bumpy trails, deep mud, and steep hills that would be way too tough or tiring for you to climb on foot!

THE EASY PULL. A comfortable, light pull at the lever's tip feels easy, but it travels a long distance. 	TRADING DISTANCE. The lever amplifies your small effort, turning a large hand movement into a tiny internal shift. 	MULTIPLYING FORCE. The force on the plunger is vastly greater than your pull at the lever! 
INEFFICIENT (LEAKY) POWER. If seals fail, energy is wasted, not multiplied. I'm pulling, but nothing's happening! I'm pulling, but nothing's seal!  If seals fail, energy is wasted, not multiplied.	ENGINEERING THE CURE (SEALS). Our seals hold the line! High-n-friction-resistant ring on a plunger.  Engineers design high-pressure seals to contain the immense force and keep it efficient.	THE RESULT: IMMENSE BRAKING POWER. Instant, strong braking! The short, incredibly powerful push generates massive, efficient braking force for control and speed.  The short, incredibly powerful push generates massive, efficient braking force for control and speed.

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Week 2: Mechanical Advantage and the Power of Strategy

Workbook Challenges

The Math of Motocross: Suppose the distance from the pivot bolt to the brake plunger is 1 inch. The distance from the pivot bolt to your fingers at the end of the handle is 5 inches.

- What is the mechanical advantage of this lever? (Hint: Divide the effort distance by the load distance)
- Answer: _____

Engineering Challenge: If a rider with smaller hands moves their fingers closer to the pivot bolt so they can reach the brake handle easier, will it take more muscle force or less muscle force for them to stop the dirt bike?

(Hint: Remember the Distance Secret! Think about what happens to your superpower strength when you get closer to the pivot point.)

Key Concepts

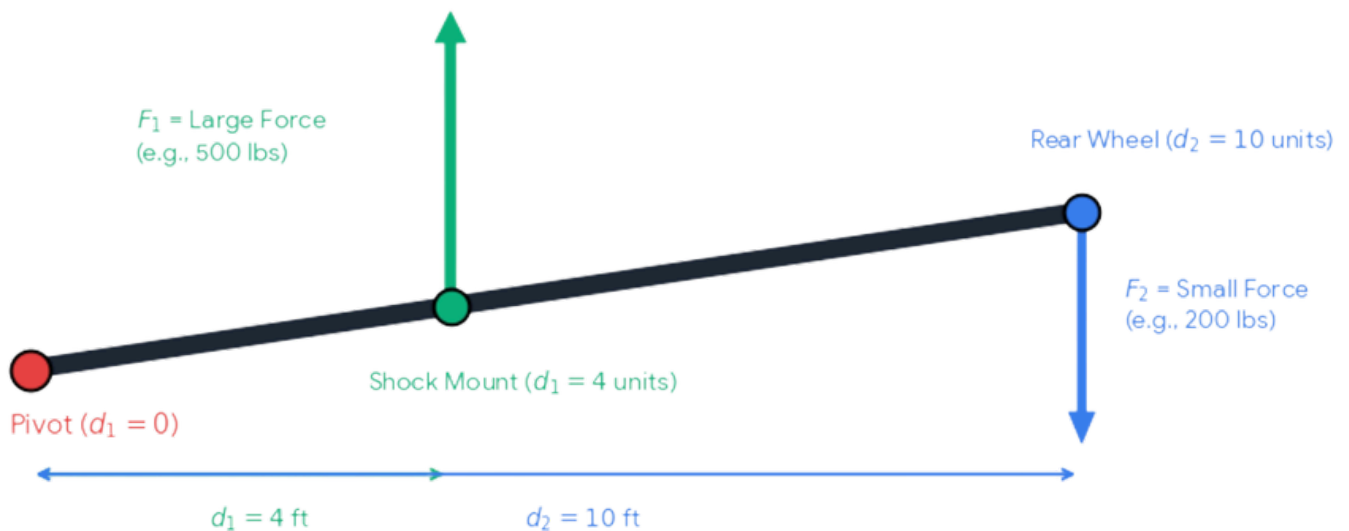
- The Balancing Act (Torque Balance): Imagine two kids on a seesaw. For the seesaw to stay completely still and balanced, the twisting force (called torque) on Cash's side has to exactly equal the twisting force on Maddie's side. If the forces match perfectly, nobody moves!
- The Distance Secret (Inverse Proportion): This is where you can trick a heavy load! A smaller push can easily balance a giant weight if it is farther away from the pivot point. Because distance and force work like a tag-team, moving your hands further down a lever gives you superpower strength, allowing a little bit of muscle to lift something huge!

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Dirt Bike Swingarm: Torque Balance ($F_1 \cdot d_1 = F_2 \cdot d_2$)



In dirt bike dynamics, this special mix of balance and distance is what keeps a dirt bike steady and safe when it carries a heavy load. This is called the law of rotational equilibrium! Torque isn't just raw engine power; it is the twisting or spinning force you apply around a fixed pivot point, like a bolt or a hinge.

For any part of a dirt bike to stay balanced and perfectly still, the twisting power (torque) on one side has to exactly match the twisting power on the other side. Because force and distance work like a tag-team, a small squeeze from your hand over a long distance can easily balance a giant, heavy force acting over a tiny distance!

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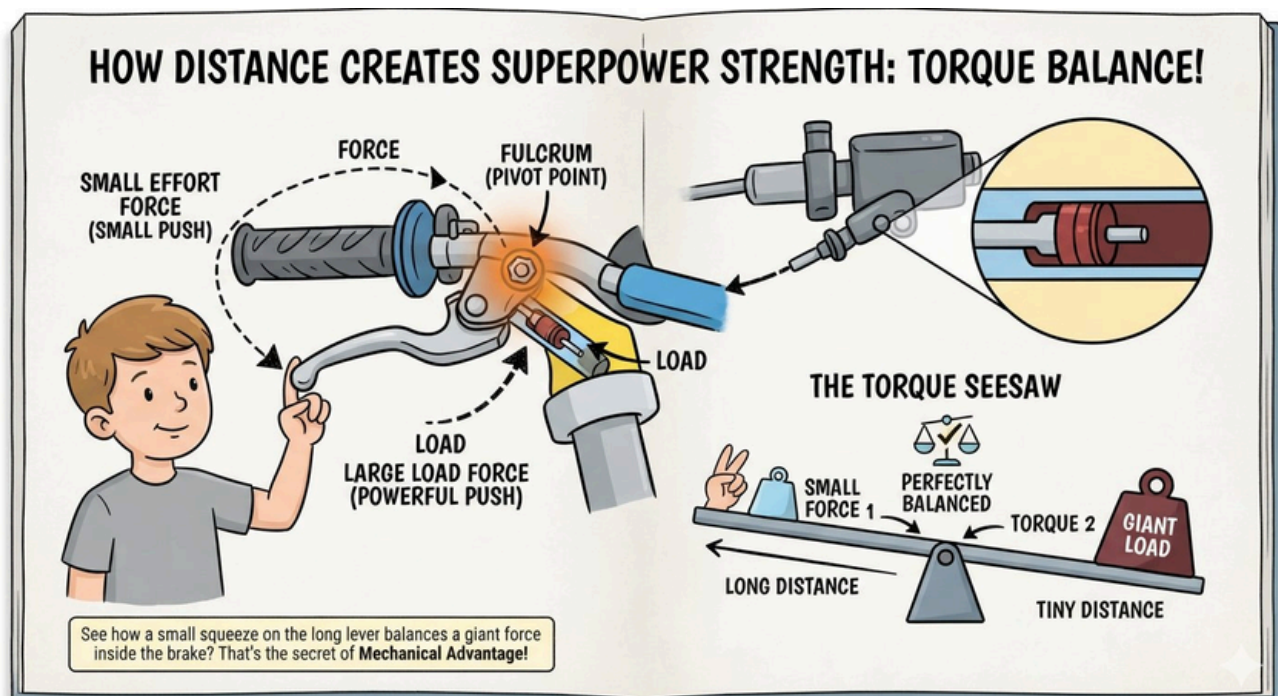
Week 2: Mechanical Advantage and the Power of Strategy

Vocabulary Check!

Fill in the blanks using the new engineering words you just learned:

Word Bank: equilibrium, smaller, spinning

- Torque is the special twisting or _____ force applied around a fixed pivot point.
- When all the forces on a dirt bike are perfectly balanced and steady at rest, the bike is in a state of rotational _____.
- Because force and distance work like a tag-team, a _____ force acting over a larger distance can easily balance a massive force acting over a tiny distance.



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Week 2: Mechanical Advantage and the Power of Strategy

Think of torque balance like a playground seesaw—but instead of two kids balancing, a dirt bike uses it to keep the whole motorcycle from flipping over or breaking under pressure!

Torque (pronounced tork) is simply a twisting force. Anytime you use a tool to turn a bolt, or use your hand to turn a doorknob, you are making torque. In physics, staying balanced means the twist pushing clockwise has to perfectly match the twist pushing counter-clockwise.

Here is the big secret of Inverse Proportion: A tiny force spread out over a long distance has the exact same twisting power as a massive force crammed into a short distance!

1. The Seesaw Under the Seat (The Swingarm)

Look at the metal beam holding the rear wheel to the bike (this is called the **swingarm**). It connects to the center of the frame with one big pivot bolt, acting just like the middle pivot of a seesaw.

- **The Super-Strong Short Side:** The engine's metal drive chain pulls on this beam very close to that center bolt. Because that distance is super short, the chain has to pull with a **HUGELY massive force** to move the bike.
- **The Easy Long Side:** The rear wheel sits way out at the far end of the beam, a much longer distance away from the center bolt. Because that arm is so long, it only takes a **much smaller force** from the ground pushing up on the tire to perfectly balance that angry engine chain!

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Worksheet: Torque & The Seesaw Secret

Fill in the blanks using the words from the Word Bank below to crack the code of dirt bike balance!

Word Bank: massive, torque, swingarm, seesaw, smaller, counter-clockwise, long

Part 1: What is Torque?

1. Think of torque balance like a playground _____—but instead of two kids balancing, a dirt bike uses it to stay steady!
2. _____ is simply a twisting or spinning force, like turning a doorknob or tightening a bolt.
3. For a dirt bike to stay balanced, the twist pushing clockwise has to perfectly match the twist pushing _____.

Part 2: The Big Distance Secret

1. Because of inverse proportion, a tiny force spread out over a _____ distance has the exact same twisting power as a massive force crammed into a short distance.
2. The metal beam holding the rear wheel to the bike is called the _____.
3. The engine's chain pulls very close to the center bolt. Because this distance is super short, the chain has to pull with a _____ force.
4. The rear wheel sits way out at the far end of the beam. Because that distance is long, it takes a much _____ force from the ground to balance the system.

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Week 2: Mechanical Advantage and the Power of Strategy

2. Squeezing the Clutch (The Easy Handle Trick)

Up on the handlebars, you have a lever to pull the clutch. Inside the engine, there are incredibly stiff steel springs holding the clutch together. If you tried to squeeze those springs with your bare hands, you couldn't do it!

- **The Long Handle Saves the Day:** The clutch lever gives you a long distance from the pivot screw. By grabbing the very outside tip of the handle, you use a large distance.
- **The Big Trade-Off:** Because your hand is far away from the pivot, a light, easy squeeze of your fingers (small force) easily balances and overcomes those crushing engine springs (large force). If you tried to squeeze the lever right next to the pivot screw where the distance is tiny, your hand wouldn't be strong enough!

3. Adjusting the Back Wheel (Changing the Teeter-Totter)

When a mechanic loosens or tightens a dirt bike chain, they can slide the back wheel forward or backward in its slot. This changes the length of our "seesaw" arm:

- **Slid Backward (Long Seesaw):** This makes the distance longer. Now, when the tire hits a bump on the track, it has more leverage over the shock absorber. The exact same bump will now feel softer and squishier to the rider.
- **Slid Forward (Short Seesaw):** This shortens the distance. Now the tire has less leverage, and it requires a much harder slam from the track to squish the rear shock, making the ride feel stiff and bumpy.

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Week 2 Worksheet: Mechanical Advantage & Strategy

Word Bank: forward, springs, tiny, backward, tip, seesaw, large

Fill in the blanks using the secret engineering words from the Word Bank below!

Part 1: Squeezing the Clutch

- Inside the dirt bike engine, there are incredibly stiff steel _____ holding the clutch together.
- By grabbing the very outside _____ of the clutch handle, you are using a large distance from the pivot screw.
- Because your hand is far away from the pivot, a light, easy squeeze of your fingers turns into a small force that easily overcomes a _____ force inside the engine.
- If you try to squeeze the handle right next to the pivot screw where the distance is _____, your hand won't be strong enough!

Part 2: Adjusting the Back Wheel

- Sliding the back wheel forward or backward in its slot changes the length of our bike's _____ arm.
- When the rear wheel is slid _____, the distance is longer, giving the tire more leverage so bumps feel softer and squishier.
- When the rear wheel is slid _____, the distance is shorter, giving the tire less leverage so the ride feels stiff and bumpy.

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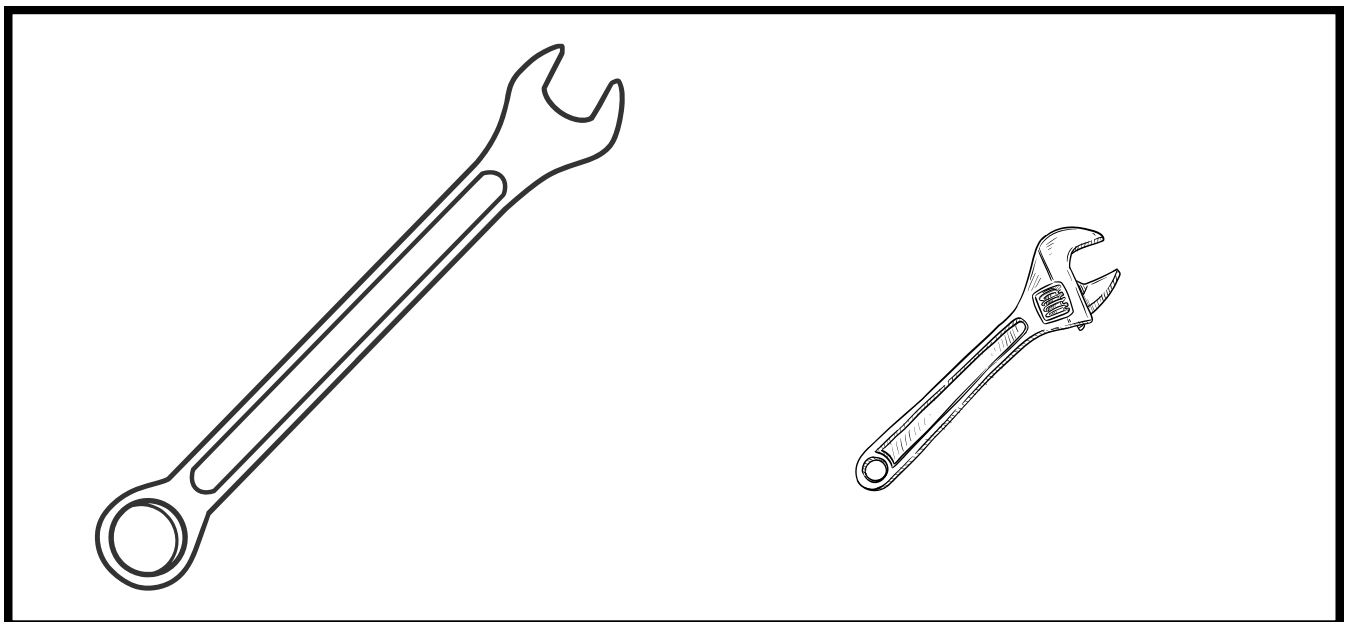
Week 2 Worksheet: Mechanical Advantage & Strategy

Torque is just a fancy engineering word for spinning power or twisting force! Imagine twisting a tight lid off a jar of peanut butter, turning a doorknob, or revving the throttle on a dirt bike. Anytime you use muscle or engine power to twist or turn something around a pivot point, you are making torque. The harder you twist, the more torque you create!

When you mix torque with Mechanical Advantage, it turns into a real superpower. Mechanical advantage means using a tool—like a long wrench or a long brake handle—to trade distance for force. If you try to twist a tight, rusty bolt on a dirt bike using just your short fingers, you won't have enough torque to move it.

But if you use a long wrench, your hand moves a much longer distance around the bolt. That long distance multiplies your torque, turning a light push from your hand into a giant, crushing twist that breaks the bolt loose easily!

Circle the wrench below that has the ability to have more torque:



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week 2:
Mechanical
Advantage
and the
Power of
Strategy

1 What is TORQUE?
(It's not just speed!)

Torque (τ) is a **twisting** force. You apply a **force (F)** at a **distance (d)** from the pivot. The rule: $\tau = F \times d$!

Mechanic Mike

Cash

F (FORCE)

d (DISTANCE)

2 The SEE-SAW OF STABILITY!

The total twist clockwise must **EQUAL** the total twist counter-clockwise for balance!

1000 lbs (F_1)

d_1

100 lbs (F_2)

d_2

TRACK IMPACT

CHAIN PULL

1000 lbs (F_1)

rd_1

FULCRUM

Small Force $\times$ Large Distance = Huge Force $\times$ Small Distance!

3 THE EASY CLUTCH TRICK!

This tip is easy! F_1 is tiny!

Grabbing the **tip** gives you massive leverage (Torque) over those hard internal engine springs!

Small F Long d

My arm hurts! Squeezing here is brutal!

BIG F Short d

Cash

4 TRACK ADJUSTMENTS!

AXLE SLID BACK
 $d_2 = \text{Long}$

Longer Arm = More Leverage over the Shock! Feels push!

SOFT RIDE

AXLE SLID FORWARD
 $d_2 = \text{Short}$

Shorter Arm = Less Leverage! Shock feels stiff!

STIFF RIDE

Vocabulary Check:

- Torque: is a **twisting** force from the pivot
- Inverse Proportion: a torque
- Leverage: longe leverage
- Fulcrum: Fulcrum
- Pivot: compresment fulcrum
- Equilibrium: is equilibrium

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The Three Classes of Levers

Levers are grouped into three different classes depending on where the Fulcrum (pivot point), Effort (your push or pull), and Load (the weight or object you are moving) are located.

A great trick to remember the order of what is in the middle is the acronym

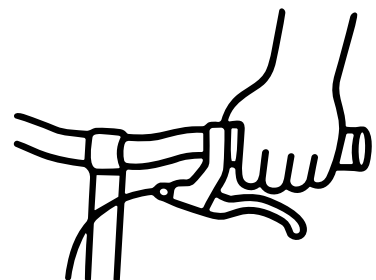
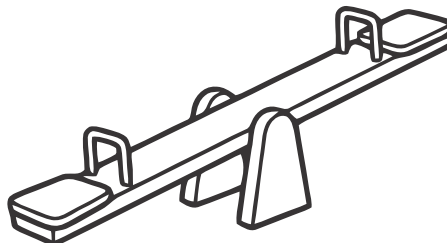
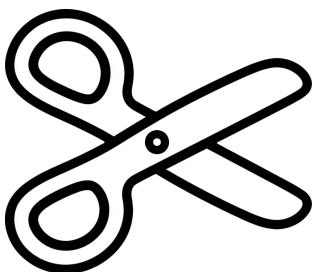
F-L-E:

- Fulcrum is in the middle = 1st Class
- Load is in the middle = 2nd Class
- Effort is in the middle = 3rd Class

First-Class Levers

The Fulcrum is in the middle, between your effort and the load.

- Front Brake Handle: Your fingers squeeze the outside tip (Effort), the handle pivots on the bolt in the middle (Fulcrum), and the inside tip pushes the brake plunger (Load).
- Seesaw / Teeter-Totter: Two friends sit on opposite ends while the balance point (Fulcrum) stays right in the center.
- Scissors: The screw holding the blades together is the Fulcrum in the middle, your fingers provide the Effort on one side, and the paper being cut is the Load.
- Pry Bar or Wrench: The tool pivots against a surface or bolt (Fulcrum) to lift or loosen a heavy object.



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Second-Class Levers

The Load is in the middle, between the fulcrum and your effort. This multiplies your force for giant lifting power!

- Dirt Bike Stand: The stand pivots on the ground (Fulcrum), your foot pushes down on the lever arm (Effort), and the heavy bike sits right in the middle (Load) to be lifted up.
- Wheelbarrow: The front wheel on the ground is the Fulcrum, the heavy dirt or rocks sit in the middle (Load), and you lift up on the handles (Effort).
- Nutcracker: The hinge at the very end is the Fulcrum, the hard nut goes in the middle (Load), and you squeeze the handles at the opposite end (Effort).

Third-Class Levers

The Effort is in the middle, between the fulcrum and the load. This multiplies speed and distance instead of power.

- Your Leg on the Kick-Starter: Your hip/knee acts as the fixed pivot point (Fulcrum), the muscles in the middle of your leg stomp down (Effort), and your boot pushes the kick-start lever at the bottom (Load) to fire up the engine!
- Tweezers or Tongs: The connected end is the Fulcrum, your fingers squeeze right in the middle (Effort), and the tiny object you are grabbing is at the tips (Load).
- Fishing Rod: Your back hand holds the bottom steady (Fulcrum), your front hand pushes or pulls in the middle (Effort), and the fish is pulled up at the far end of the line (Load).

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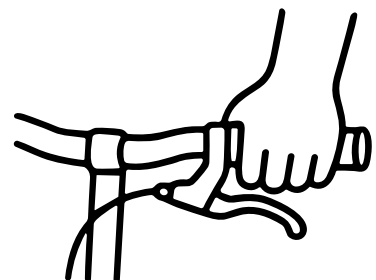
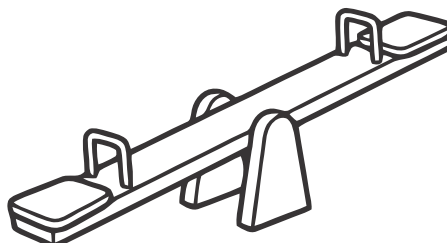
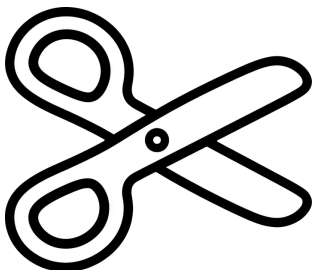
Week 2 Worksheet: Mechanical Advantage & Strategy

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2. The _____ is the magic pivot point that stays perfectly still while the lever turns around it.
3. The _____ is the input force or the muscle power you apply to the lever to make it move.

In a _____-class lever, the fulcrum is right in the middle (like a _____ or your _____!).

In a _____-class lever, the heavy load is in the middle, making it easy to lift massive weights (like a _____ or a _____!).

In a _____-class lever, your muscle effort is applied in the middle, which helps move things fast over a long distance (like a h _____ or your _____).

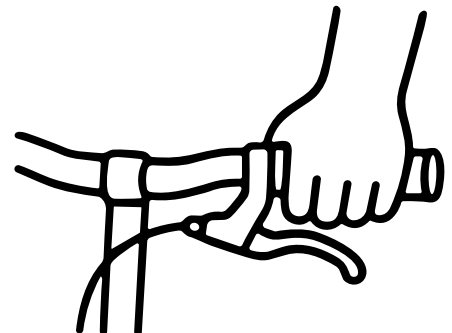
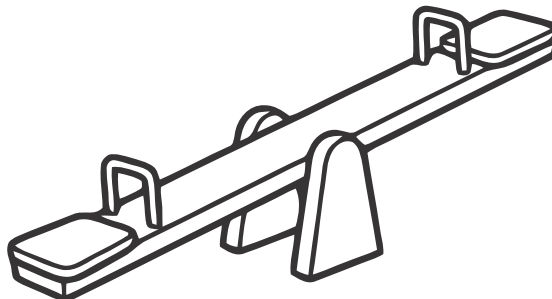
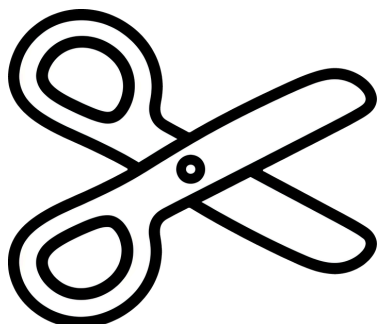
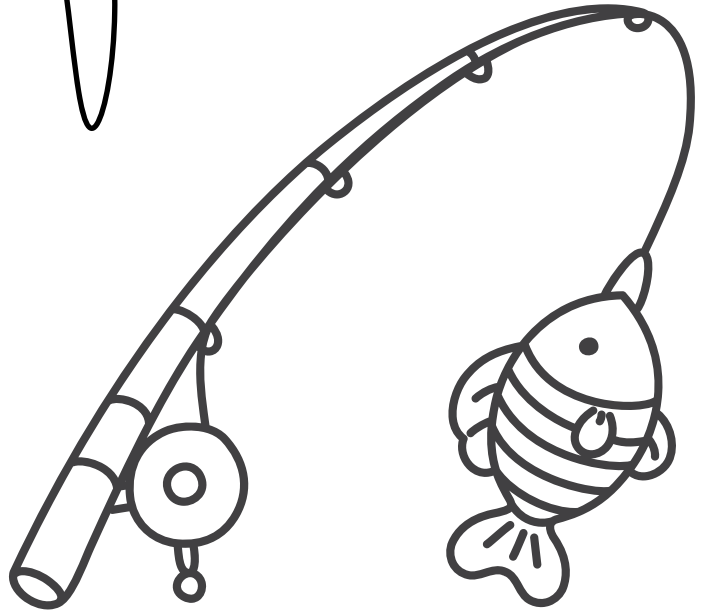
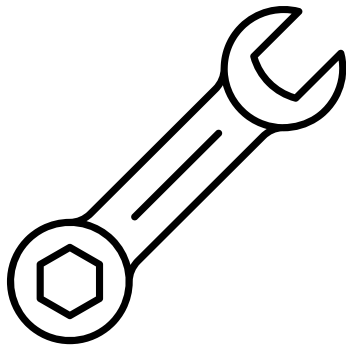
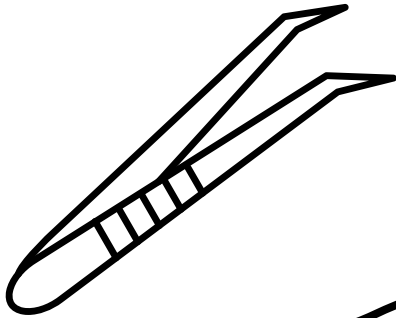
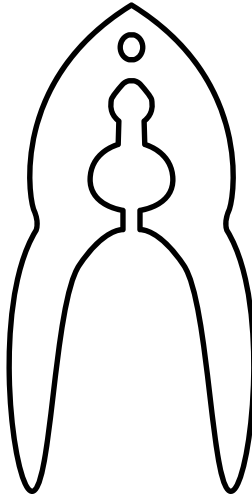
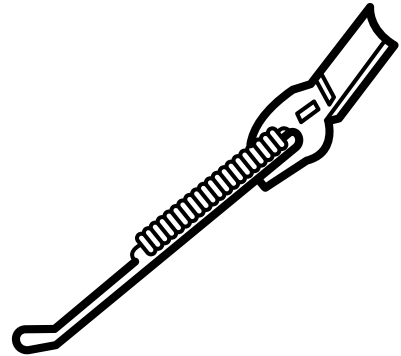
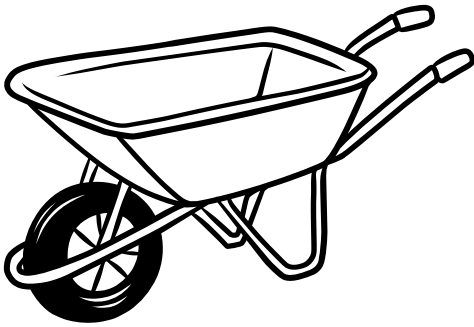


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Label the First, Second and Third class of Levers Below:



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Week 2: The Rear Swing Arm and High-Speed Suspension

Daily Scripture Focus

"But those who hope in the Lord will renew their strength. They will soar on wings like eagles; they will run and not grow weary, they will walk and not be faint." — Isaiah 40:31

Dirt bikes hit rough bumps and hard landings on the track, but their engineered suspension systems absorb all that shocking force so the rider can keep going without their muscles getting completely exhausted.

The Engineering Science

Levers don't always make your muscles stronger. Sometimes, engineers design them to trade power for speed and distance instead! Let's look at a giant lever at the back of the motorcycle: the swingarm. The swingarm is the large metal beam that connects the rear wheel to the main frame of the bike.

Here is how the three parts of a lever look on the swingarm:

- **Fulcrum:** The main pivot bolt where the swingarm attaches to the center frame. This is the exact spot that stays still while the arm swings up and down.
- **Effort:** The rear shock absorber. It pushes hard on the swingarm right near the frame pivot to control the motorcycle's bounce.
- **Load:** The rear wheel itself. This is the part that takes a heavy hit whenever you blast over a bump or land a big jump.

Swingarm Blueprint: Fill-in-the-Blanks!

Use your vocabulary words (Fulcrum, Effort, Load) to label the correct parts of the bike below:

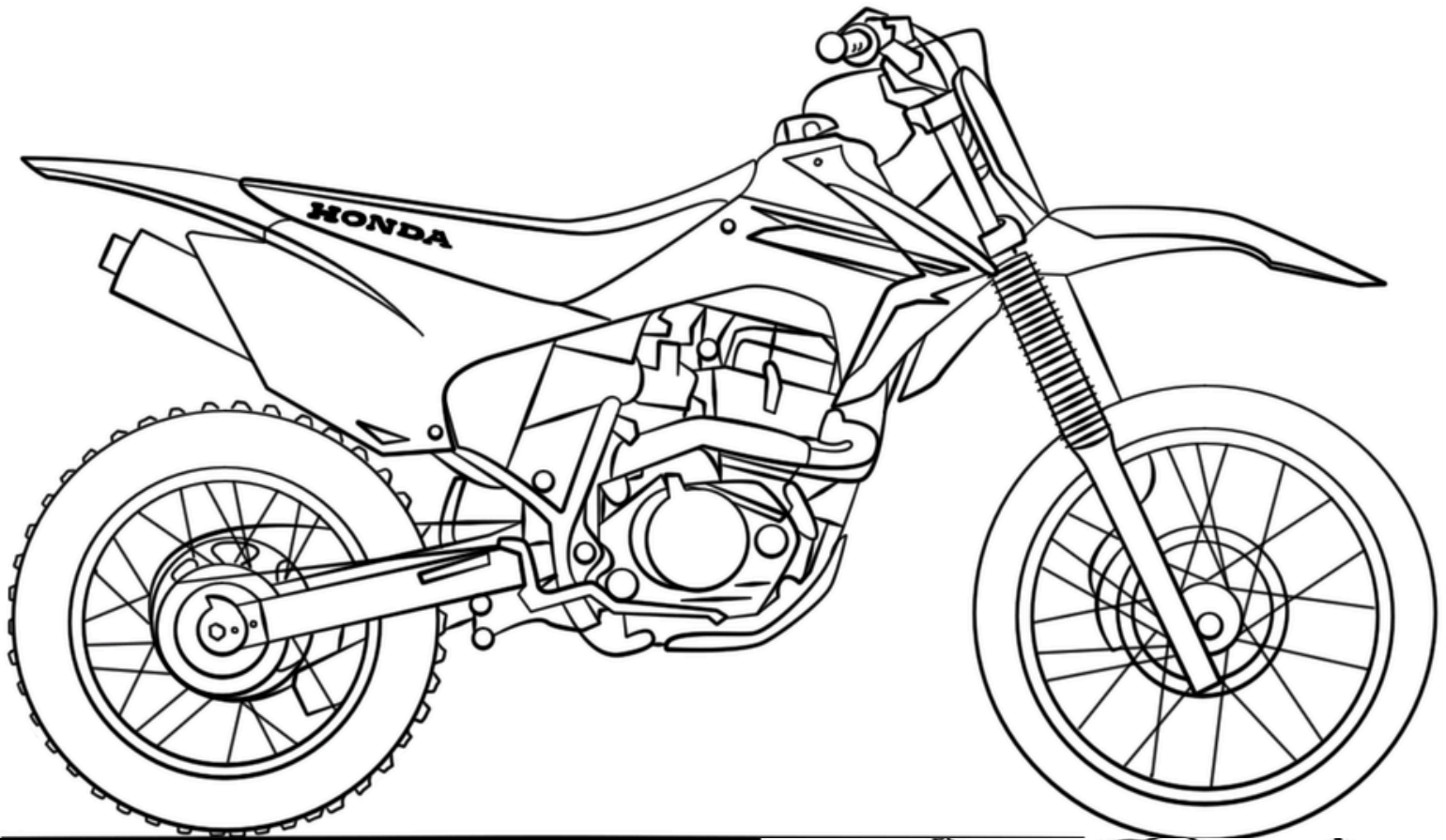
1. _____: The rear shock absorber, which pushes down on the swingarm near the frame pivot.
2. _____: The pivot bolt where the swingarm attaches to the center frame.
3. _____: The rear wheel hitting a bump at the very back of the bike

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Riding with God's Strength & A Tuned Suspension!

In dirt bike dynamics, Isaiah 40:31 perfectly describes what it feels like to ride with a professionally tuned suspension system versus trying to tackle a brutal track on a rigid frame with no bounce at all. A real race track is a relentless obstacle course packed with square-edged ruts, breaking bumps, and heavy landing impacts from giant jumps.

If your dirt bike had no suspension to soak up these brutal blows, all that crushing impact force would shoot straight out of the dirt and smash directly into your wrists, lower back, and legs. Your muscles would wear out almost instantly, causing rapid and total physical exhaustion!

But a dirt bike's suspension is beautifully engineered to constantly absorb and reset, renewing the bike's capacity to handle every single bump. This mechanical blessing allows riders like Cash, Levi and Madison to sail effortlessly lap after lap, flying over rough terrain without growing weary—just like how God promises to renew our strength when we trust in Him!

INTRODUCTION: THE SWINGARM

Levers do not always make forces stronger. Sometimes, they increase speed and distance. **Feel the rear of the dirt bike, the swingarm.**

This is different!



The swingarm is the large metal piece connecting the rear wheel.

ANATOMY OF A REAR LEVER

Let's identify the parts.

Everything is connected!



Defining the components for analysis.

IDENTIFYING THE L-E-R (LEVER, EFFORT, RESISTANCE)

1. FULCRUM: Pivot bolt at frame.
2. EFFORT: Shock pushes down near the pivot.
3. LOAD: Rear wheel hitting a bump.



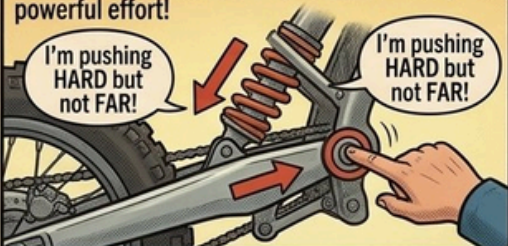
Pinpointing the lever elements.

THE EFFORT PUSH

The rear shock absorber exerts force over a very short distance near the fulcrum. It's a short, powerful effort!

I'm pushing HARD but not FAR!

I'm pushing HARD but not FAR!



The shock's short-range, powerful force.

THE LOAD TRAVELS

Because the Effort is near the fulcrum and the Load is at the far end, the rear wheel must travel a large distance quickly to keep pace.

Look at me GO!



The wheel's long-range, fast movement.

SUMMARY: TRADING FORCE FOR DISTANCE & SPEED

Maximum travel for minimum shock travel!
This lever configuration trades force (the powerful shock push) for increased distance and speed of the rear wheel's movement. Great for handling big bumps! Result: SMOOTH RIDE!



Trading forces to manage rough terrain with speed.

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Week 2: The Rear Swing Arm and High-Speed Suspension

Because your bike's rear shock absorber pushes on the swingarm right between the center pivot bolt and the back wheel, the swingarm works as a Third-Class Lever.

Third-class levers actually do less lifting work for you instead of more. This means the heavy rear shock has to stomp down with thousands of pounds of crushing force just to handle a few hundred pounds of force pushing up at the wheel! Why in the world would engineers build a dirt bike this way? Because of a super-cool distance trade-off!

When the stiff shock absorber squishes down just 1 inch, it forces the rear wheel to travel a whopping 4 inches! This gives the rear wheel tons of room to zoom up and down quickly, allowing your dirt bike to safely soak up massive jumps, deep mud ruts, and bumpy tracks at high speeds without crashing.

Workbook Challenges: Classify the Lever!

Fill in the blanks to compare the two types of levers you studied this week:

- The handlebar brake handle is a _____-class lever because the pivot point (fulcrum) is in the middle. (Correction hint: Remember your F-L-E rule! When the Fulcrum is in the center, it's a first-class tool!)
- The rear swingarm is a _____-class lever because the pushing effort from the shock is right in the middle.

LEVERS



Simply The Way Things Work – Mechanics & Movement

Name: _____ Date: _____

Instructions: Read the sentences carefully and fill in the missing words using the terms from the word bank below.

Word Bank

1. load
2. fulcrum
3. effort
4. lever
5. balance
6. direction
7. distance

- A _____ is a rigid bar or board that rests on a fixed point and is used to move heavy objects.
- The fixed point or pivot upon which the lever turns or pivots is called the _____.
- The heavy weight or resistance that you are trying to move with the lever is known as the _____.
- The force or push that you apply to the lever to make it move is called the _____.
- When the force on one side of the pivot equals the force on the other side, the system is in _____.
- A lever can change the size of your push and can also change the _____ in which the force moves.
- By changing the _____ between the effort, the load, and the fulcrum, a lever makes heavy work much easier to do.