

Spring Scales

Turn off all electronic devices

Observations about Spring Scales

- They move downward during weighing
- They take a little time to settle
- They're only accurate when everything is at rest

4 Questions about Spring Scales

1. What exactly is a spring scale measuring?
2. How does a spring scale measure weight?
3. What is scale's dial or meter actually reporting?
4. Why must you stand still on a spring scale?

Question 1

Q: What exactly is a spring scale measuring?

A: The scale measures the weight of the object being weighed

- The object has both a mass and a weight
- On the earth's surface, they are proportional
 - Object's mass is the same everywhere
 - Object's weight varies with gravity

Mass as a Measure

- An object's mass doesn't depend on location
- Measuring an object's mass can be done directly:
 - Exert a known force on the object
 - Measure the object's acceleration
 - Divide the force by the acceleration to find the mass
- Measuring acceleration accurately is difficult

Weight as a Measure

- An object's weight depends on location (gravity)
- Measuring an object's weight is done indirectly:
 - The object's weight is a force that acts on the object
 - There is no direct way to measure that weight
- Fortunately, measuring weight indirectly is easy
- Spring scales measure weight, not mass

Question 2

Q: How does a spring scale measure weight?

A: The scale measures the upward force needed for equilibrium

- Spring scale measures weight using equilibrium
 - Exert an upward force on the object
 - Adjust that force until the object is in equilibrium
 - Measure the amount of that upward force
 - Report that amount as the object's weight

Using a Spring to Measure Weight

- Springs provide adjustable, measurable forces
- Recall that when an object is at equilibrium,
 - individual forces sum to zero—they cancel perfectly.
 - object is inertial—it remains motionless or it coasts.
- A spring scale
 - uses a spring to support the object
 - allows the spring and object to reach equilibrium
 - reports the spring's force as the object's weight

Question 3

Q: What is scale's dial or meter actually reporting?

A: It's reporting how far the spring has distorted

- A free spring adopts its equilibrium length
- When distorted, its ends experience forces that
 - act to restore the spring to its equilibrium length
 - make the equilibrium length a stable equilibrium
 - are proportional to the distortion

Hooke's Law

The restoring force on the end of a spring is equal to a spring constant times the distance the spring is distorted. That force is directed opposite the distortion.

$$\text{restoring force} = - \text{spring constant} \cdot \text{distortion}$$

A Spring Scale

- To weigh an object with a spring scale,
 - support the object with a spring,
 - let the object become motionless at equilibrium,
 - and measure the distortion of the spring.
- The spring constant relates distortion to force
- Once the spring constant is calibrated, reporting the spring's distortion is equivalent to reporting the restoring force that is supporting the object

Question 4

Q: Why must you stand still on a spring scale?

A: It reports your correct weight only when you are in equilibrium

- If you are not in equilibrium,
 - the spring force is unrelated to your weight
- Since an accelerating object is not at equilibrium,
 - you mustn't bounce on a scale!
 - you must wait for the scale to settle before reading!

Oscillation

- When you first load a scale, it bounces
 - It accelerates toward a new equilibrium
 - It then coasts through that equilibrium
 - It then accelerates back toward the new equilibrium
 - It returns and overshoots many times
- It oscillates around its stable equilibrium
 - To settle at equilibrium, it must get rid of energy
 - Friction and air resistance help it settle

Summary about Spring Scales

- The spring stretches during weighing
- This stretch is proportional to object's weight
- The scale measures the spring's stretch
- The scale reports that stretch as object's weight