Ramps

Turn off all electronic devices

Observations About Ramps

It's difficult to lift a heavy wagon straight up

It's easer to push a heavy wagon up a ramp

The required push depends on the ramp's steepness

The gentler the slope of the ramp,

- the smaller the required push on the wagon
- the farther you must push the wagon along the ramp to raise it upward

5 Questions about Ramps

1. Why doesn't a wagon fall through a sidewalk?
2. Why does a sidewalk support a wagon perfectly?
3. How does a wagon move as you let it roll freely on a ramp?
4. Why is it harder to lift a wagon up than to lower a wagon down?
5. Why is it easier to pull a wagon up a ramp than to lift it up a ladder?

Question 1

Q: Why doesn't a wagon fall through a sidewalk?

A: The sidewalk pushes up on it and supports it.

The sidewalk and the wagon cannot occupy the same space

The sidewalk exerts a support force on the wagon that

- prevents the wagon from penetrating the sidewalk's surface
- acts perpendicular to the sidewalk's surface
- is exerted upward by the horizontal surface of sidewalk
- can cancel the wagon's downward weight

Question 2

Q: Why does a sidewalk support a wagon perfectly?

A: The sidewalk and wagon negotiate by denting and undenting.

The wagon and sidewalk dent one another slightly

- The more they dent, the more strongly they push apart
- Sidewalk's force on wagon affects wagon's net force and acceleration
- Wagon bounces up and down

When wagon experiences zero net force, it is at equilibrium

- At equilibrium, the wagon moves at constant velocity
- Above equilibrium, the wagon accelerates downward
- Below equilibrium, the wagon accelerates upward

Friction-like effects cause the wagon to settle at equilibrium

Newton's Third Law

For every force that one object exerts on a second object, there is an equal but oppositely directed force that the second object exerts on the first object.

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Misconception Alert

The forces two objects exert on one another must be equal and opposite, but each force of that <u>Newton's third law pair</u> is exerted on a different object, so those forces do not cancel one another.

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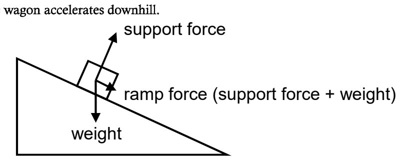
Question 3

Q: How does a wagon move as you let it roll freely on a ramp?

A: The wagon accelerates downhill.



The wagon experiences two forces: its weight and a support force

The sum of those forces is the <u>ramp force</u>: a small downhill net force

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Pushing the wagon up the Ramp

To start the wagon moving uphill
- push wagon uphill more than the downhill ramp force
- net force is uphill, so wagon accelerates uphill

To keep the wagon moving uphill
- push wagon uphill just enough to balance ramp force
- wagon continues uphill at constant velocity

To stop the wagon moving uphill,
- push wagon uphill less than the downhill ramp force
- net force is downhill, so wagon accelerates downhill

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Question 4

Q: Why is it harder to lift a wagon up than to lower a wagon down?

A: You do work on the wagon when you lift it.
The wagon does work on you when you lower it.

<u>Energy</u> – a conserved quantity
- it can't be created or destroyed
- it can be transformed or transferred between objects
- is the capacity to do work

<u>Work</u> – mechanical means of transferring energy

work = force · distance

(where force and distance are in same direction)

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Transfers of Energy

Energy has two principal forms
- <u>Kinetic energy</u> – energy of motion
- <u>Potential energy</u> – energy stored in forces

Your work transfers energy from you to the wagon
- Your chemical potential energy decreases
- wagon's gravitational potential energy increases

The wagon's <u>gravitational potential energy</u>
- is defined as zero at the reference altitude (e.g., ground level)
- is the work you must do on the wagon to lift it to its new altitude
- is equal to the wagon's weight times its increase in altitude

gravitational potential energy = weight · altitude

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Question 5

Q: Why is it easier to pull a wagon up a ramp than to lift it up a ladder?

A: On the ramp, you do work with a small force over a long distance. On the ladder, you do work with a large force over a small distance.

For a shallow ramp: work = Force · **Distance**

For a steep ramp: work = Force · Distance

For a ladder: work = **Force** · Distance

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Mechanical Advantage

Mechanical advantage is doing the same work, using a different balance of force and distance

A ramp provides mechanical advantage

- You lift wagon with less force but more distance
- Your work is independent of the ramp's steepness

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Summary about Ramps

Ramp reduces the force you must exert to lift the wagon

Ramp increases the distance you must push to lift the wagon

You do work pushing the wagon up the ramp

The ramp provides mechanical advantage

- It allows you to push less hard on the wagon
- but you must push the wagon for a longer distance
- Your work is independent of ramp's steepness