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
- How hard you must push depends on the ramp's steepness
- The gentler the slope of the ramp,
  - the smaller the push you must exert on the wagon
  - the longer the distance you must push the wagon to raise it upward

5 Questions about Ramps

1. Why doesn't a wagon fall through a sidewalk?
2. Why does a sidewalk perfectly support a wagon?
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: it is directed straight up
- balances wagon's downward weight

Question 2

Q: Why does a sidewalk perfectly support a wagon?

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

The wagon and sidewalk dent one another slightly

- the more they dent, the harder they push apart
- the wagon accelerates up or down in response to net force
- the wagon bounces up and down during this negotiation

The wagon comes to rest at equilibrium—zero net force

The Wagon and Sidewalk Negotiate

If the wagon and sidewalk dent one another too much,

- each one pushes the other away strongly
- the wagon accelerates away from the sidewalk

If the wagon and sidewalk dent one another too little,

- each one pushes the other away weakly (or not at all)
- the wagon accelerates toward the sidewalk

If the wagon and sidewalk dent one another just right,

- the wagon is in equilibrium (zero net force)

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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 Newton's third law pair is exerted on a different object, so those forces do not cancel one another.

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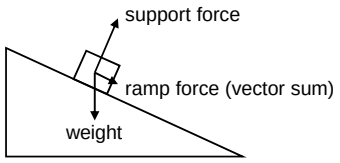
Question 3

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 ramp force: 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.

- Energy – a conserved quantity
  - it can't be created or destroyed
  - it can be transformed or transferred between objects
  - is the capacity to do work
- Work – 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
  - Kinetic energy – energy of motion
  - Potential energy – energy stored in forces
- Your work transfers energy from you to the wagon
  - Your chemical potential energy decreases
  - wagon's gravitational potential energy increases

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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
  - but you must push for a longer distance
  - Your work is independent of ramp's steepness