

Ramps 1

Ramps

Ramps 2

Introductory Question

- Can a ball ever push downward on a table with a force greater than the ball's weight?
- A. Yes
- B. No

Ramps 3

Observations About Ramps

- It's difficult to lift a heavy cart straight up
- It's easier to push a heavy cart up a ramp
- The ease depends on the ramp's steepness
- Gradual ramps involve gentler pushes
- Gradual ramps involve longer distances

Ramps 4

4 Questions about Ramps

- Why doesn't the cart fall through the ramp?
- Are the cart and ramp pushing on each other?
- Why is it easier to push the cart up a ramp?
- Is there a physical quantity that's the same for any trip up the ramp, regardless of its steepness?

Ramps 5

Question 1

- Why doesn't the cart fall through the ramp?
 - Why doesn't a ball fall through a table?
 - Is the table pushing up on the ball?
 - How can an upward push prevent falling?

Ramps 6

Support Forces

- A support force
 - prevents the ball from penetrating the table's surface
 - points directly away from the table's surface
- Forces along surface are friction (ignore for now)

Adding up the Forces

- As it sits on the table, the ball experiences
 - its weight downward
 - a support from the table upward
- Since the ball isn't accelerating,
 - the sum of forces (the net force) on the ball is zero
 - so the support force must balance ball's weight!
- Since cart isn't accelerating into ramp,
 - the ramp's support force must keep cart on surface

Question 2

- Are the cart and ramp pushing on each other?
- Are the ball and table pushing on each other?
 - Is the table pushing on the ball?
 - Is the ball pushing on the table?
 - Which is pushing harder?

Clicker Question

- If you push on a friend, will that friend always push back on you?
- A. Yes
B. No

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.

Clicker Question

- If you push on a friend who is moving away from you, how will the force you exert on your friend compare to the force your friend exerts on you?
- A. You push harder
B. Your friend pushes harder
C. The forces are equal in magnitude

Forces Present (Part 1)

- For the ball resting on the table, the forces are
 1. On ball due to gravity (its weight) } zero
 2. On ball due to support from table } acceleration
 3. On table due to support from ball } pair
- These forces all have the same magnitude
- Where is the other 3rd law pair?

Forces Present (Part 2)

1. On earth due to gravity from the ball } 3rd law
 2. On ball due to gravity from the earth } pair
 3. On ball due to support from table } 3rd law
 4. On table due to support from ball } pair
- Forces 2 and 3 aren't a Newton's 3rd law pair!
 - when equal in magnitude, ball doesn't accelerate
 - when not equal in magnitude, ball accelerates!

Introductory Question (revisited)

- Can a ball ever push downward on a table with a force greater than the ball's weight?
- A. Yes
B. No

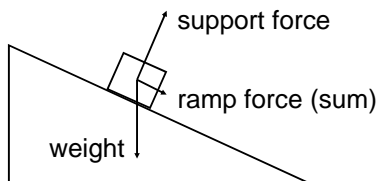
Misconception Alert

- While the forces two objects exert on one another must be equal and opposite, the net force on each object can be anything.
- Each force within an equal-but-opposite pair is exerted on a different object, so they don't cancel directly.

Question 3

- Why is it easier to push the cart up a ramp?
 - Why does the ramp's steepness matter?
 - Why does the cart tend to roll downhill?

Forces on a Cart on a Ramp



- Ramp force causes cart to accelerate downhill

Clicker Question

- If I pull uphill on the cart just hard enough to balance the downhill ramp force, the cart will
 - be motionless.
 - move at constant velocity.

Balanced Cart on Ramp

- If you balance the ramp force,
 - the net force on the cart will be zero,
 - the cart won't accelerate,
 - and it will coast uphill or downhill or remain at rest
- The more gradual the ramp,
 - the more nearly its weight and the support balance,
 - the smaller the ramp force on the cart,
 - and the easier it is to balance the ramp force!

Question 4

- Is there a physical quantity that's the same for any trip up the ramp, regardless of its steepness?
- What physical quantity is the same for
 - a long trip up a gradual ramp
 - a medium trip up a steep ramp
 - a short trip straight up a vertical ramp

Energy and Work

- 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

$$\text{work} = \text{force} \cdot \text{distance}$$
 (where force and distance in same direction)

Work Lifting a Cart

- Going straight up: Force is large, Distance is small

$$\text{work} = \text{Force} \cdot \text{Distance}$$
- Going up ramp: Force is small, Distance is large

$$\text{work} = \text{Force} \cdot \text{Distance}$$
- The work is the same, either way!

Mechanical Advantage

- Mechanical advantage:
 - Doing the same amount of work, but altering the balance between force and distance
- A ramp provides mechanical advantage
 - You can raise a heavy cart with a modest force,
 - but you must push that cart a long distance.
 - Your work is independent of the ramp's steepness

The Transfer 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 cart
 - You do work on the cart
 - Your chemical potential energy decreases
 - The cart's gravitational potential energy increases

Summary about Ramps

- Ramp supports most of the cart's weight
- You can easily balance the ramp force
- You do work pushing the cart up the ramp
- Your work is independent of ramp's steepness
- The ramp provides mechanical advantage
 - It allows you to push less hard
 - but you must push for a longer distance