that's how i roll

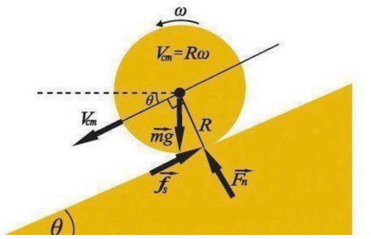
PHY131H1F
- Class 12

Today:

• Action / Reaction Pairs

• Newton's Third Law

• Ropes and Pulleys



Pre-class Reading Quiz. (Chapter 7)

Newton's Third Law States

A. Any object at rest or moving with a constant velocity will continue to stay at rest or move with a constant velocity unless acted upon by a net outside force.

B. The acceleration of an object is proportional to the net force on it, and inversely proportional to the object's mass.

C. If object 1 exerts a force on object 2, object 2 exerts an equal and opposite force on object 1.

D. All bodies attract one another with a force that is proportional to the product of their masses, and inversely proportional to the square of the distance between them.

Last day I asked at the end of class:

Consider the following reasoning, and identify the mistake:

"When you pull a wagon, Newton's 3rd Law states that the wagon pulls back on you with an equal and opposite force. These forces should cancel each other. So it is impossible to accelerate the wagon!"

ANSWER:

First sentence is correct: the wagon really does pull back on you with an equal opposite force that you pull on the wagon!

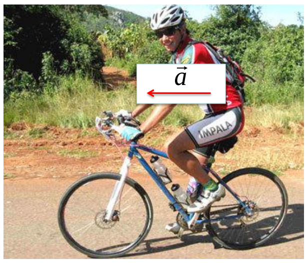
Second and third sentences are not correct: **forces cannot cancel each other if they are on different objects.**

The forward static friction on your feet is larger than the backward rolling friction on the wheels of the wagon, so the system of **you and the wagon** has a forward net force, provided by the Earth (static friction). That is why you both accelerate.

Static Friction and Rolling Without Slipping

- A cyclist is pushing on his pedals, and therefore accelerating to the left.
- What is the direction of the force of static friction of the ground on the **back wheel?**

A. Left
B. Right
C. Up
D. Down
E. zero



Static Friction and Rolling Without Slipping

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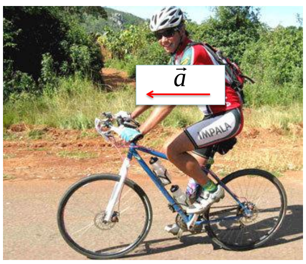

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Newton's Third Law

If object 1 acts on object 2 with a force, then object 2 acts on object 1 with an equal force in the opposite direction.

$$\vec{F}_{1\,\text{on}\,2} = -\vec{F}_{2\,\text{on}\,1}$$

FIGURE 7.1 The hammer and nail are interacting with each other.

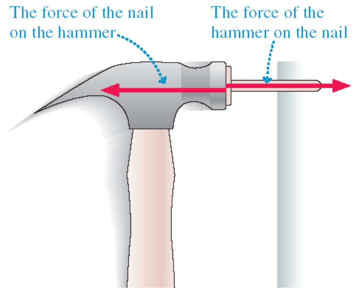
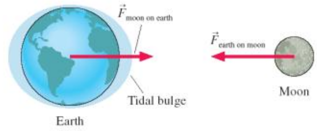
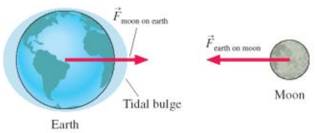


FIGURE 7.3 The ocean tides are an indication of the long-range gravitational interaction of the earth and the moon.



- The entire Earth accelerates toward the Moon, due to this pulling force.
- To find the total acceleration, you use the force as calculated for the centre-to-centre distance.
- Since $F_G = GMm/r^2$, the force on the ocean nearer to the moon will be greater, so it will accelerate more than the rest of the Earth, bulging out.

FIGURE 7.3 The ocean tides are an indication of the long-range gravitational interaction of the earth and the moon.



- Similarly, since $F_G = GMm/r^2$, the force on the ocean further from the moon will be less, so it will accelerate ***less*** than the rest of the Earth, remaining behind, forming a bulge.
- In general, tidal effects tend to ***stretch*** objects both toward and away from the object causing the tides.

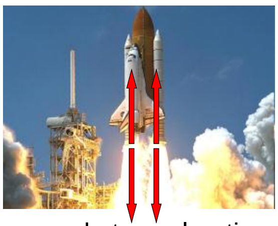
Announcement

- Starting tomorrow in Practicals you will be in NEW TEAMS! Your TAs will assign you to a new pod and you will work with your new team for the rest of the semester.
- Forming effective teams with strangers is a life skill.
- Before Practicals this week, please read pages 1-6 of the Teamwork Module Activity 1, which is on the Practicals page of the portal

Identifying Action / Reaction Pairs

- Consider an accelerating car.
- **Action:** tire pushes on road.
- **Reaction:** road pushes on tire

Identifying Action / Reaction Pairs



- Consider a rocket accelerating upward.
- **Action:** rocket pushes on gas.
- **Reaction:** gas pushes on rocket

Identifying Action / Reaction Pairs

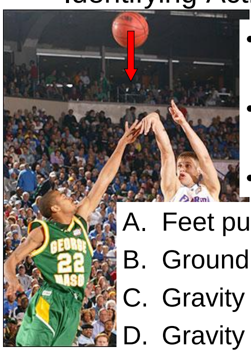
- **Action force:** man pulls on rope to the left.
- **Reaction force?**

A. Feet push on ground to the right.
B. Ground pushes on feet to the left.
C. Rope pulls on man to the right.
D. Gravity of Earth pulls man down.
E. Gravity of man pulls Earth up.

Identifying Action / Reaction Pairs

- Consider a stationary man pulling a rope.
- **Action:** man pulls on rope
- **Reaction:** rope pulls on man

Identifying Action / Reaction Pairs



- Consider a basketball in freefall.
- **Action force:** gravity of Earth pulls ball down.
- **Reaction force?**

A. Feet push ground down.
B. Ground pushes feet up.
C. Gravity of Earth pulls man down.
D. Gravity of ball pulls Earth up.
E. Air pushes ball up.

Identifying Action / Reaction Pairs

$$a = \frac{F}{m}$$

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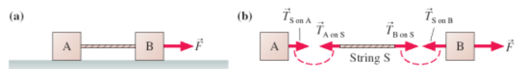
- Consider a basketball in freefall.
- **Action:** Earth pulls on ball
- **Reaction:** ball pulls on Earth

Practicals Question

- A block of mass M_1 rests on top of a block of mass M_2 that rests on a frictionless horizontal surface.
- A light rope attached to M_2 is used to pull on it with a force F.
- When M_2 is pulled (and therefore accelerates), the frictional force between the blocks is not big enough to keep M_1 stuck to it, hence M_1 slides on M_2.
- The coefficient of kinetic friction between the two blocks is μ_k.
- What's going on here?
- In Practicals this week you will be asked to find the acceleration of each block!

The Massless String Approximation

FIGURE 7.22 The string's tension pulls forward on block A, backward on block B.



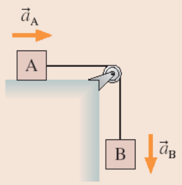
Often in physics problems the mass of the string or rope is much less than the masses of the objects that it connects. In such cases, we can adopt the following **massless string approximation**:

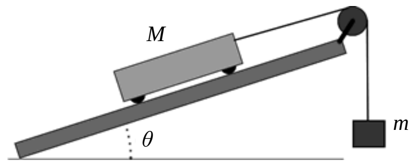
$$T_{\text{B on S}} = T_{\text{A on S}} \qquad \text{(massless string approximation)}$$

Pulleys

Acceleration constraints

Objects that are constrained to move together must have accelerations of equal magnitude: $a_A = a_B$. This must be expressed in terms of components, such as $a_{Ax} = -a_{By}$.



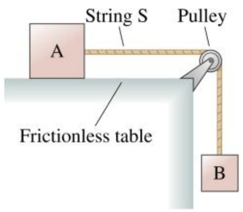


Example

A cart of mass M is on a track which is at an angle of θ above the horizontal. Rolling friction between the cart and the track is negligible.
The cart is attached to a string which goes over a pulley; the other end of the string is attached to a hanging mass, m. The mass of the string and pulley are both negligible. The friction in the pulley is negligible.
What is the acceleration of the cart?

Challenge Question

In the figure to the right, is the tension in the string greater than, less than, or equal to the force of gravity on block B?



A. Equal to
B. Greater than
C. Less than

Before Class 13 on Wednesday … my last class!

- Please read Knight **Chapter 8**
- Something to think about: A ball is whirled on a string in a vertical circle. As it is going around, the tension in the string is

A. constant.
B. greatest at the top of the motion
C. greatest at the bottom of the motion
D. greatest somewhere in between the top and bottom.