Flashlights

Question:
If you remove the 2 batteries from a working flashlight and reinstall them backward so that they make good contact inside, will the flashlight still work?

Observations About Flashlights
- They turn on and off with a switch
- More batteries usually means brighter
- The orientation of multiple batteries matters
- Flashlights dim as batteries age
- Sometimes smacking a flashlight brightens it

A Battery
- Battery “pumps” charge from – end to + end
  - Chemical potential energy is consumed
  - Electrostatic potential energy is produced
- Current undergoes a rise in voltage
  - Alkaline cell: 1.5 volt rise
  - Lead-acid cell: 2.0 volt rise
  - Lithium cell: 3.0 volt rise
- Chain of cells produces larger voltage rise

A Light Bulb
- Structure
  - Contains a protected tungsten filament
  - Filament conducts electricity, but poorly
- Filament barely lets charge flow through it
  - Electrostatic potential energy is consumed
  - Thermal energy is produced
- Current undergoes a drop in voltage
  - Two-cell alkaline flashlight: 3.0 volt drop

A Simple Circuit
- A battery – the energy source
- A wire – the outgoing current path
- A light bulb – the energy destination (the load)
- A wire – the return current path
Circuits 1

• Steady current requires a circuit path (a loop)
  – Charge mustn’t accumulate anywhere
  – A closed conducting loop avoids accumulation
• Steady current flow requires energy
  – Currents lose energy (and voltage) in conductors
  – Missing energy becomes thermal energy
  – Lost energy must be replaced

Circuits 2

• A circuit can transport energy
  – Current obtains energy from a battery
  – Current delivers energy to a light bulb
  – Current starts the trip over again

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Recharging a Battery

• Forward (discharging) current flow
  – Battery “pumps” charge from – end to + end
  – Current undergoes voltage rise
  – Battery’s chemical potential energy is consumed
• Reverse (recharging) current flow
  – Circuit “pushes” charge from + end to – end
  – Current undergoes voltage drop
  – Battery’s chemical potential energy is replenished

Positive Charge

• Current points in the direction of positive flow
• Flow is really negative charges (electrons)
• It’s hard to distinguish between:
  – negative charge flowing to the right
  – positive charge flowing to the left
• We pretend that current is flow of + charges
• It’s really – charges flowing the other way

Short Circuits

• If a conducting path bridges the load
  – Current bypasses the load
  – Circuit is abbreviated or “short”
• No appropriate energy destination (load)
• Energy loss and heating occurs in the wires
• A recipe for fires!
### Power
- Power is energy per unit of time
- Power is measured in joules/second or watts
- Batteries are power sources
- Loads are power consumers

### Battery Power
- Current: units of charge pumped per second
- Voltage rise: energy given per unit of charge

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\text{current} \cdot \text{voltage rise} = \text{power produced}
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### Load Power
- Current is units of charge passed per second
- Voltage drop: energy taken per unit of charge

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\text{current} \cdot \text{voltage drop} = \text{power received}
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