

GEOS 24705 / ENST 24705 / ENSC 21100

2018

## Lecture 11

### Electricity II

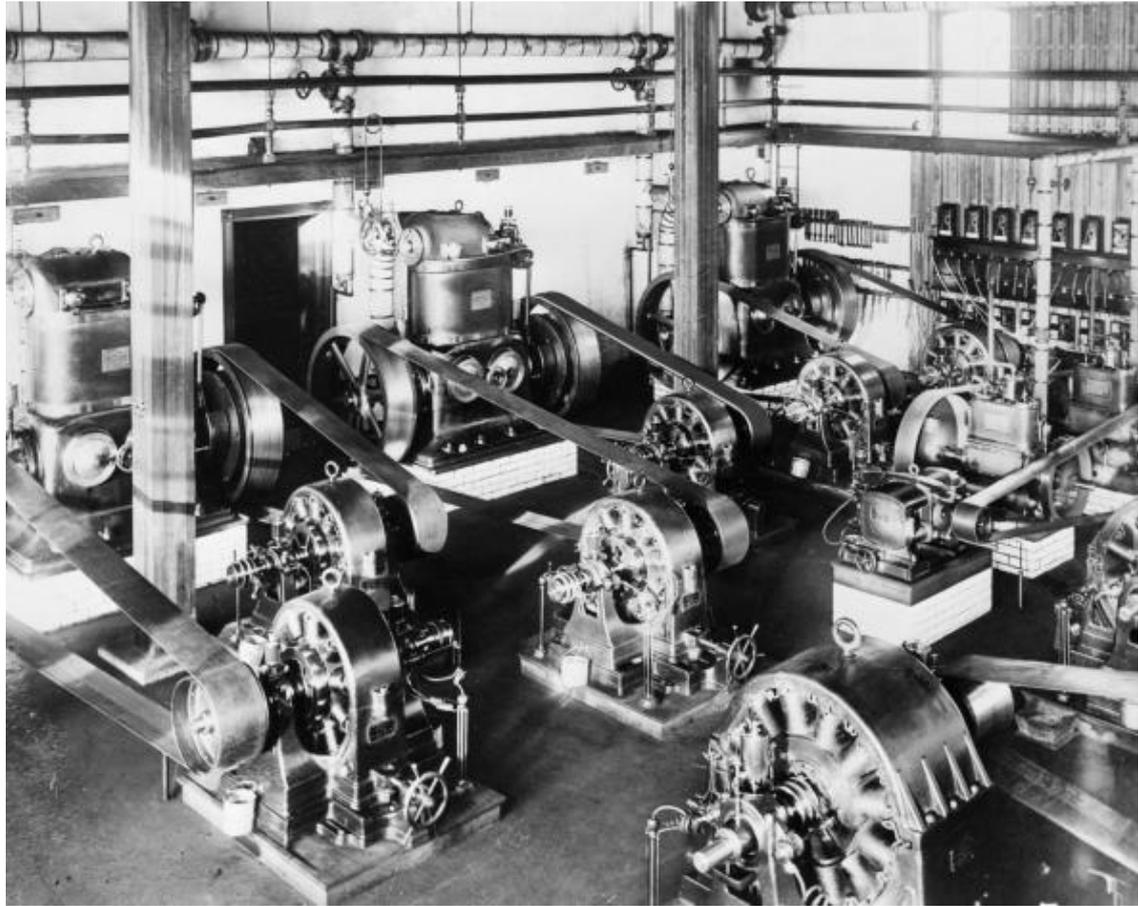
# Motor and generator are converse of each other

## 1) Generator

Turning something (*in the presence of a magnetic field*) can make electricity (*i.e., convert work to electrical energy*).

## 2) Motor

Electrical energy (*given the presence of a magnetic field*) can turn something (*i.e. convert electric energy to work*)



Westinghouse commercial AC generating station, 1888

Electricity has a **chicken-and-egg problem** – why develop a motor without a generator to drive it? Why develop a generator without a market for its power?

# Batteries allow electricity research to start with motors



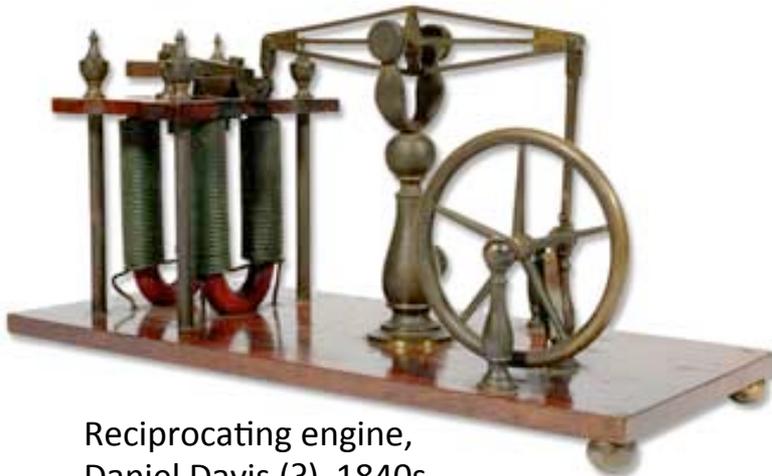
Rotating wire in Hg,  
Faraday, 1830s



Rotating electromagnet,  
Wm. Ritchie, 1833



Rotating electromagnet,  
Wm. Sturgeon, 1838



Reciprocating engine,  
Daniel Davis (?) 1840s



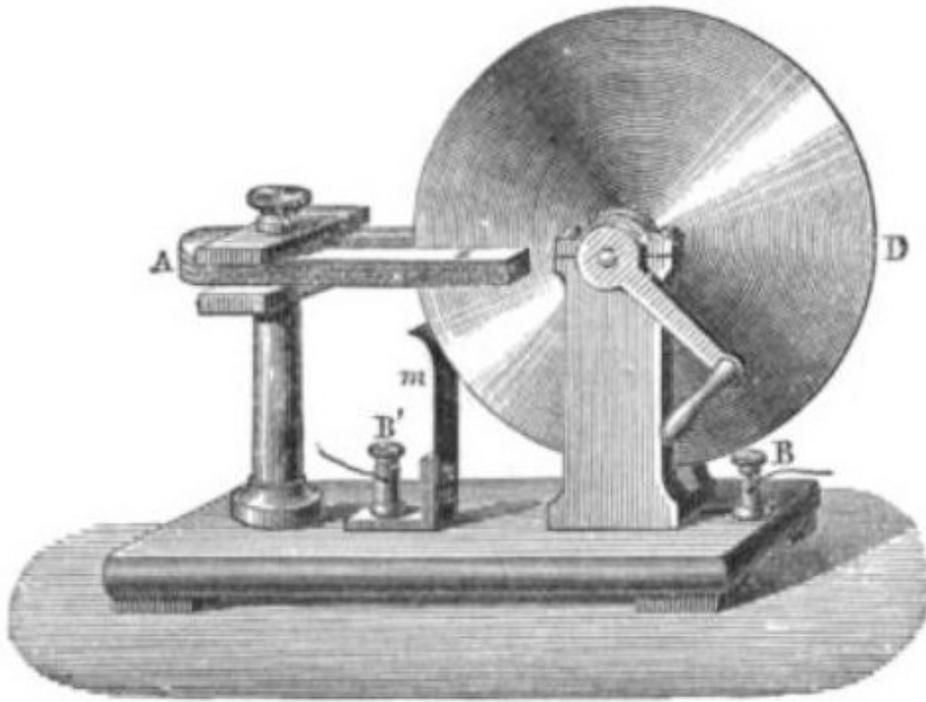
Revolving armature engine,  
Daniel Davis 1848



DC electric fan, Edison 1898

# Generators followed quickly

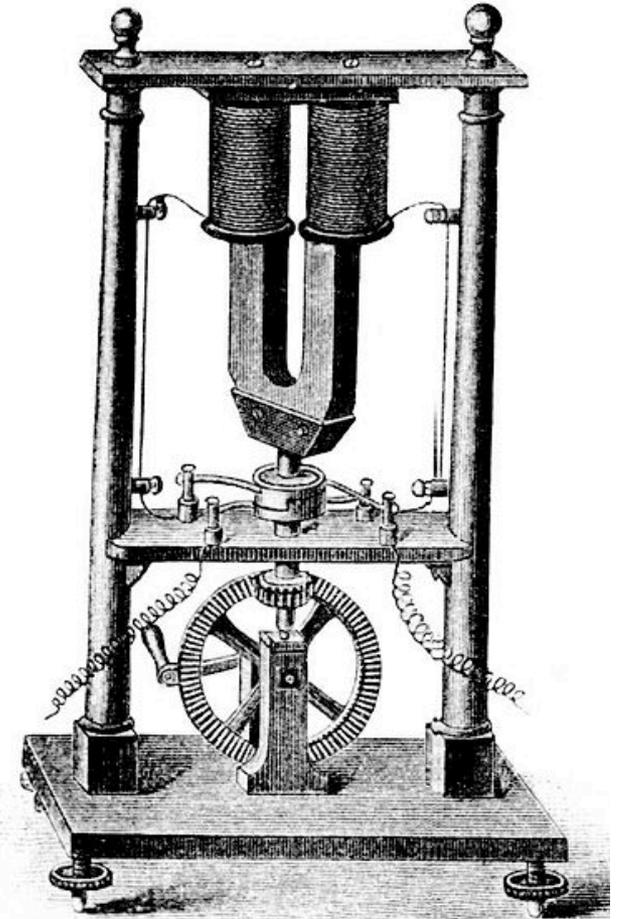
*Still only as physics demonstrations, no practical use*



Faraday's generator, 1831

A metal disk spinning between  
poles of a magnet

Source: Wikimedia, original unknown



Pixii's dynamo, 1832

A magnet spinning under coils of wire  
*Commutated DC current*

Source: Niethammer, F.; *Ein- und Mehrphasen-Wechselstrom-  
Erzeuger*; Verlag S. Hirzel; Leipzig 1906, via Wikimedia

# Lighting is a longstanding societal need

*Wall-hung oil lamp, 1800s*



*First gas streetlights 1798*



*1861 locomotive – pre-electricity  
gas or oil-powered*

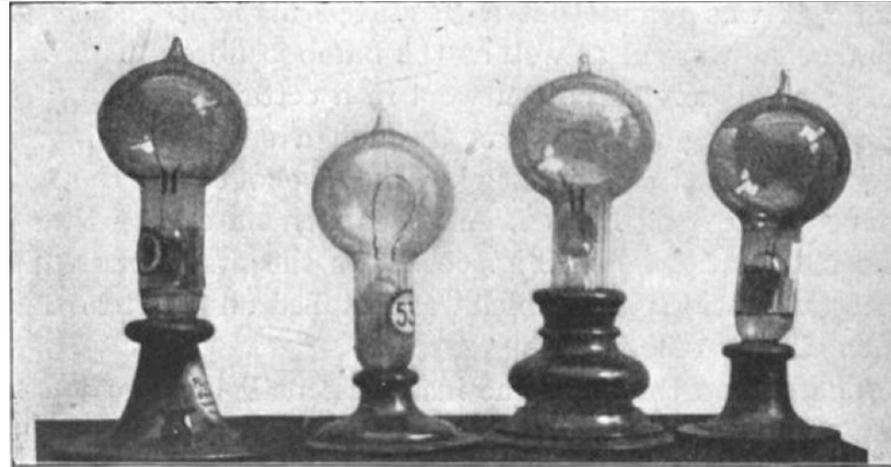
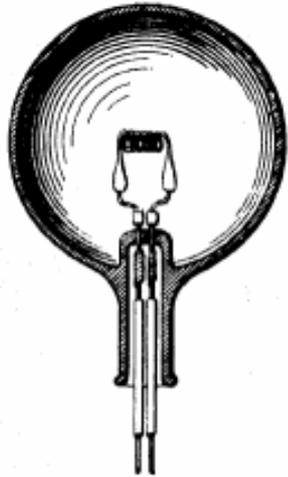


# Lighting becomes the “killer app” for electricity

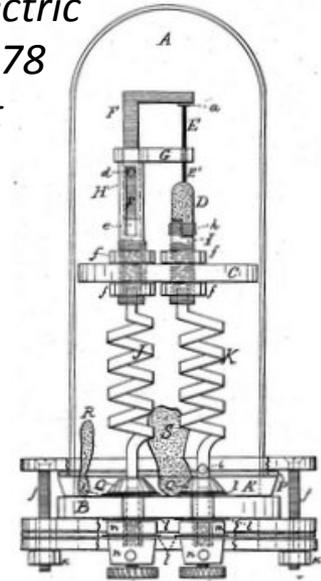
T. A. EDISON.  
Electric-Lamp.

No. 223,898.

Patented Jan. 27, 1880.



Sawyer electric  
lamp, 1878  
patent



- 1878: William Sawyer founds Electro-Dynamic Light Company, patents a lightbulb
- 1878 + 3 months: Edison forms Edison Electric Light Company (J.P. Morgan invests)
- 1879: Edison patents carbon-thread lightbulb. *Nearly a decade of litigation follows...*  
*claim: higher vacuum, more effective filament, higher resistance*
- 1880: >6000 electric arc lights are in factories, Thomson-Houston Electric Co. forms in U.S.
- 1892: Thomson-Houston merges with Edison to become General Electric
- 1890s: “War of the currents” sets the electrical standard for the United States and world
- 1904: First tungsten filament (Kuzel, Vienna) → William Coolidge at GE tries to imitate
- 1914: 88.5M incandescent bulbs are sold, 85% non-carbon

Lighting paves the way for using electricity for work

Converting electrical energy  $\leftrightarrow$  work requires a magnetic field

### Ampere's law:

current flowing in a wire generates a magnetic field

*If I flow current through a wire loop in a magnetic field it will rotate*

$\rightarrow$  *motors*

### Faraday's law:

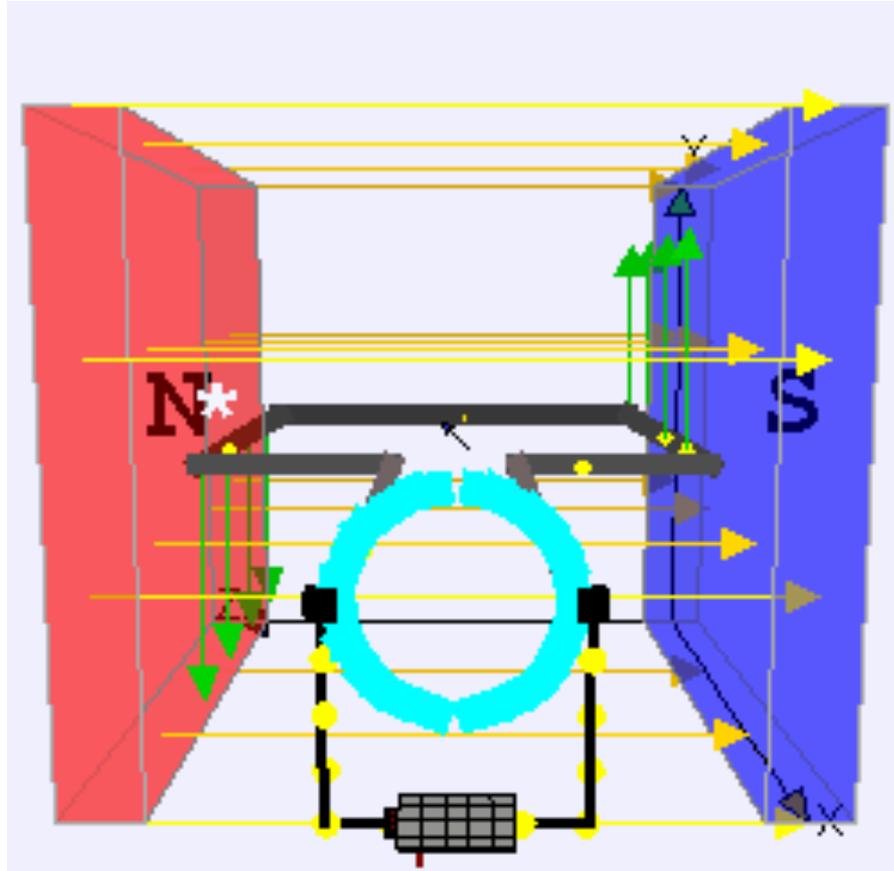
changing magnetic flux in a wire loop induces current to flow

*If I rotate a wire loop in a magnetic field it will produce a current*

$\rightarrow$  *generators*

# Force on a brushed DC motor

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[Magnetic field lines video](#)

# Force on a brushed DC motor

