British and American Rail
Iron Road – Transformation from Canal and River to Rail
Races and Competitions

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Computers for NOTETAKING ONLY
Please - NO Cell Phones, Texting, Internet use
Connecting the Continent
1830 - 1883

1830 1840 1850 1860 1870 1880

Henry
Morse
Western Union
Cornell

Joseph Henry
Samuel Morse
Connecting the Continent
1830 - 1883

1830 1840 1850 1860 1870 1880

Henry

Morse

Western Union
Cornell

Stephenson

Thomson

Stanford

Joseph Henry

Samuel Morse

1883 – ‘Sun Time’ to ‘Standard Time’
Connecting the Continent

1830 - 1883

1830 1840 1850 1860 1870 1880

Henry

Morse

Western Union
Cornell

Stephenson

Thomson

Stanford

Boston & Lowell RR - 1835

1883 – ‘Sun Time’ to ‘Standard Time’
British and American Rail

Formula: Traction and Power

History: Connecting Cities and Connecting the Continent

Vision: Railroad and Art

Boston & Lowell RR - 1835
British and American Rail

Formula: Traction and Power

History: Connecting Cities and Connecting the Continent

Vision: Railroad and Art
“A horse on an iron road would draw ten tons for one ton on a common road”
"A horse on an iron road would draw ten tons for one ton on a common road"

"The Blucher (locomotive) is worth fifty horses"
"The Blutcher (locomotive) is worth fifty horses"
George Stephenson
ENGINEER

Studied previous works
Made numerical calculations
Performed full scale tests

“The Blucher (locomotive) is worth fifty horses”
George Stephenson

ENGINEER

Studied previous works
Made numerical calculations
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Charles Sheeler’s “Rolling Power”
George Stephenson
ENGINEER

Studied previous works
Made numerical calculations
Performed full scale tests
Darlington to Stockton-on-Tees
“The First Public Railway”
Darlington to Stockton-on-Tees

“The First Public Railway”
Early British Rail Lines
George and Robert Stephenson

Liverpool → Manchester
London → Birmingham
   → Liverpool
Chester → Holyhead
The Rocket of Mr Rob’t Stephenson of Newcastle
Which drawing a load equivalent to threetimes its weight travelled at the rate of 12½ miles an hour, & with a carriage and passengers, at a rate of 24 miles
Cost per mile for fuel about three halfpence
Early British Rail Lines
George and Robert Stephenson

Liverpool → Manchester
London → Birmingham → Liverpool
Chester → Holyhead
Races and Competitions

**Fulton**  - Monopoly  - 1807

**Stephenson**  - Sales  - 1829

**Ford**  - Capital  - 1899
Races and Competitions

Fulton - Monopoly - 1807
Stephenson - Sales - 1829
Ford - Capital - 1899
## Races and Competitions

<table>
<thead>
<tr>
<th>Name</th>
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**BRIDGES**
Robert Stephenson’s ‘Britannia’
Thomas Telford’s ‘Menai Straits’
BRIDGES
Robert Stephenson’s ‘Britannia’
Thomas Telford’s ‘Menai Straits’
Robert Stephenson

Isambard Kingdom Brunel
Isambard Kingdom Brunel
### Gauge War

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### Gauge War

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Cole’s “Landscape with Dead Tree”
Force to climb a grade

Cole’s “Landscape with Dead Tree”

$W$, $w$ weight

$T$ tension
Measure weight of Loco and Cars

Demonstrate traction force needed to climb a hill

Force to climb a grade

\[ w \approx \frac{\text{rise}}{\text{run}} W \]

\[ T = w \]

W, w weight
T tension
Power to climb a grade

\[ T \approx \frac{\text{rise}}{\text{run}} \ W_{\text{total}} \]

\[ Hp = \frac{TV}{33,000} \]

Force to climb a grade

\[ w \approx \frac{\text{rise}}{\text{run}} \ W \]

\[ T = w \]

T  traction

W, w  weight

T  tension
Power to climb a grade

\[ T \approx \frac{\text{rise}}{\text{run}} W_{\text{total}} \]

\[ Hp = \frac{TV}{33,000} \]

Traction Limit – wheels slip

\[ T_{\text{max}} = 0.2 W_{\text{Loco}} \]

Friction coefficient
Demonstrate challenge of large grade when towing a large load
Demonstrate fix by increasing weight of Locomotive

Conclusions:
• Gentle grades ( < 2%)
• Heavy Locomotives
• Powerful Locomotives
Demonstrate challenge of large grade when towing a large load

Demonstrate fix by increasing weight of Locomotive

Conclusions:
• Gentle grades ( < 2%)
• Heavy Locomotives
• Powerful Locomotives

VIDEO – Wheel sparks due to slip
Demonstrate challenge of large grade when towing a large load

Demonstrate fix by increasing weight of Locomotive

Conclusions:

• Gentle grades ( < 2%)
• Heavy Locomotives
• Powerful Locomotives

Four-day Trip in 1834
Allegheny Portage Railroad - canal boats pulled up mountain by stationary steam engine and rope

Four-day Trip in 1834
Connecting Port to Industry

New York - 1825
  Erie Canal to Buffalo

Philadelphia - 1834
  Railroad and Canal to Pittsburgh

Boston - 1835
  Railroad to Lowell

Four-day Trip in 1834
Connecting Port to Industry

- New York - 1825
  Erie Canal to Buffalo
- Philadelphia - 1834
  Railroad and Canal to Pittsburgh
- Boston - 1835
  Railroad to Lowell

Albany

Buffalo
Connecting Port to Industry

New York - 1825
Erie Canal to Buffalo

Philadelphia - 1834
Railroad and Canal to Pittsburgh

Boston - 1835
Railroad to Lowell

The Dewitt Clinton
Swivel truck

American-style locomotive

British-style locomotive

Inline design
J. Edgar Thomson

1834 Georgia RR
  engineer

1848 Pennsylvania RR
  engineer

1852 Pennsylvania RR
  president

Swivel truck

American-style locomotive
J. Edgar Thomson

1834 Georgia RR  
engineer

1848 Pennsylvania RR  
engineer

1852 Pennsylvania RR  
president

Railroad supports inland growth
J. Edgar Thomson

1834  Georgia RR
      engineer

1848  Pennsylvania RR
      engineer

1852  Pennsylvania RR
      president
J. Edgar Thomson and PRR

Scientific: technological trendsetter
Social: profits returned to company
Symbolic: world’s largest transportation network

Railroads – America’s First Big Business
US Railroad Map in 1860

J. Edgar Thomson and PRR

Scientific: technological trendsetter
Social: profits returned to company
Symbolic: world’s largest transportation network

Railroads – America’s First Big Business
Chicago and St. Louis

east-west vs. north-south

railroads vs. steamboats

Civil War favors Chicago

Illinois Central Railroad attorney
Chicago and St. Louis

east-west vs. north-south

railroads vs. steamboats

Civil War favors Chicago

Land Grants hasten RR and Telegraph
Land Grants hasten RR and Telegraph

Hp = \frac{TV}{33,000}
\[ Hp = \frac{TV}{33,000} \]

Timber Trestle Bridge
Leland Stanford
1824 - 1893

1862 - 63 Governor of California
1869 Promontory Point, Utah
- Central Pacific Railroad
1885 Founded Stanford University
May 10, 1869

Leland Stanford
1824 - 1893

1862 - 63  Governor of California

1869  Promontory Point, Utah
      - Central Pacific Railroad

1885  Founded Stanford University
Leland Stanford
1824 - 1893

1862 - 63 Governor of California
1869 Promontory Point, Utah - Central Pacific Railroad
1885 Founded Stanford University
Leland Stanford

1824 - 1893

1862 - 63 Governor of California
1869 Promontory Point, Utah
    - Central Pacific Railroad
1885 Founded Stanford University

Golden Spike - Stanford University Museum of Art
Leland Stanford

River to Rail
Leland Stanford

Charles Sheeler’s “Rolling Power”
Leland Stanford

TRACTION = 0.2 W_{LOCO}

Charles Sheeler’s “Rolling Power”
TRACTION = 0.2 \( W_{\text{LOCO}} \)

POWER = \( \frac{\text{PLAN}}{33,000} \)

Charles Sheeler’s “Rolling Power”
Turner’s “Rain, Steam and Speed”
Locomotive replaces the hare

Charles Sheeler’s “Rolling Power”

\[ \text{POWER} = \frac{\text{PLAN}}{33,000} \]

\[ \text{TRACTION} = 0.2 \ W_{\text{LOCO}} \]
Inness’s “Lackawanna Valley”
Restructuring of nature

Turner’s “Rain, Steam and Speed”
Locomotive replaces the hare
Monet’s “Gare Saint Lazare”
Brings artist to landscape

Inness’s “Lackawanna Valley”
Restructuring of nature
Key Ideas

Scientific:
Traction and Power

Social:
Public: Land Grants
Private: First Big Business
River to Rail

Symbolic:
Railroads and Art

Monet’s “Gare Saint Lazare”
Brings artist to landscape