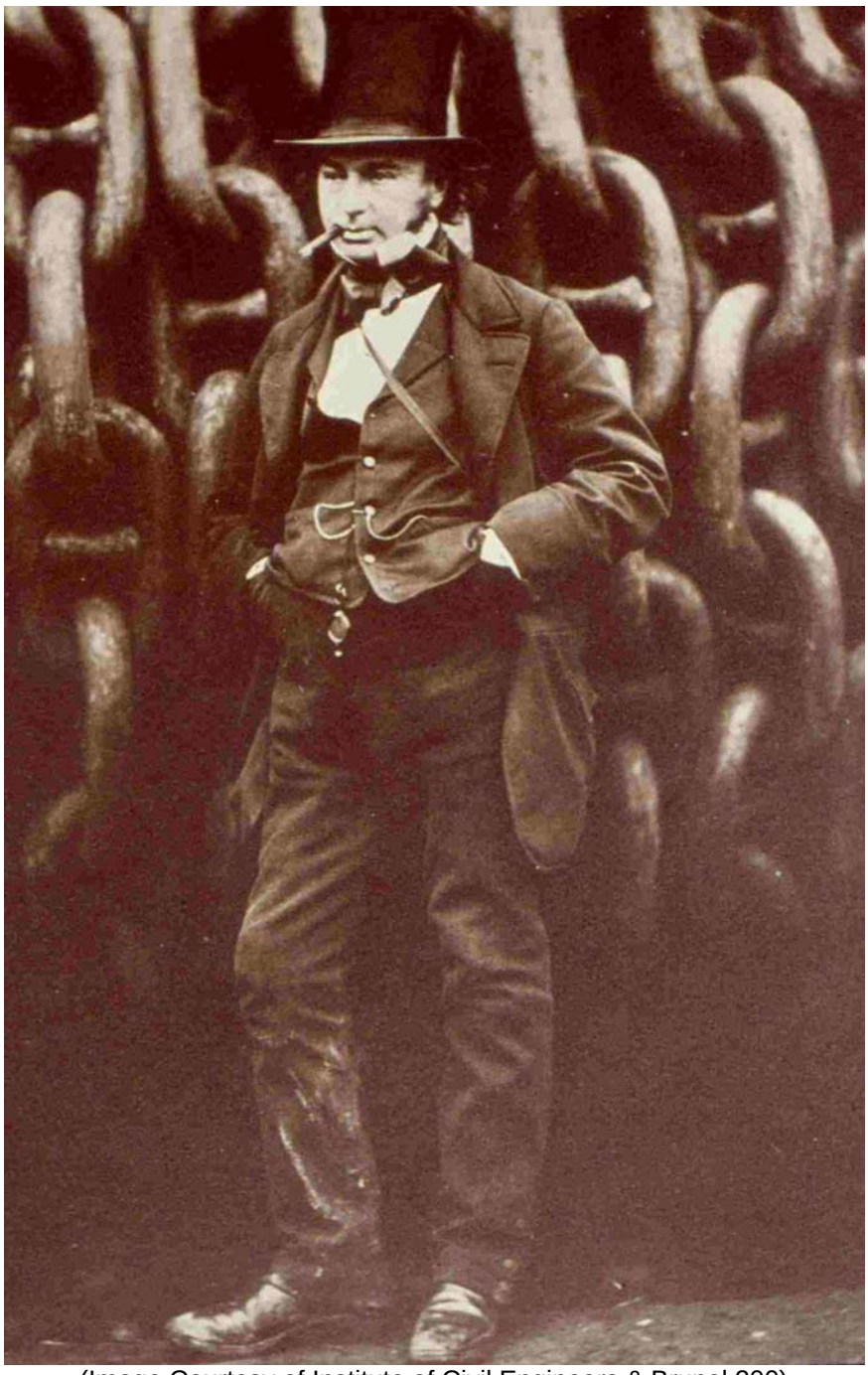
Brunel and His Contemporaries
A Victorian Engineering Legacy

Teaching Resources



(Image Courtesy of Institute of Civil Engineers & Brunel 200)

CONTENTS

1. About this Pack

These teaching resources have been produced to accompany the Brunel 200 exhibition mounted in the county as part of celebrations across the south west to mark the two hundredth anniversary of Brunel's birth.

The resources in this pack have been designed to help teachers plan lessons using Brunel's engineering legacy as a starting point. At the beginning of the pack you will find suggestions of ways in which you can familiarise your class with the use of historic sites and museums, including activities which you can do in the classroom in preparation for a visit. Those teachers covering The Victorians section of the History curriculum will find large amounts of useful material in the pack, but also included are activities which deliver several areas of the curriculum, for example geography and numeracy. Efforts have been made to include material which will have a life beyond Brunel 200.

2. Brunel: the Man and his Legacy

Isambard Kingdom Brunel was born in Portsea on 9 April, 1806 to an English mother, Sophia Kingdom, and French-born engineer father, Marc Brunel, and from the moment of his birth he was destined to become an engineer. At the age of sixteen the young Brunel went to work with his father, and together they worked on an ambitious project to construct a tunnel beneath the Thames. This early apprenticeship served him well, and in 1830, when a competition was announced to design an iron suspension bridge to span the Avon Gorge at Clifton in Bristol, it was Isambard's design that triumphed. In later years he called it "my first love, my darling". This project was characterised, as were many others in which Brunel was involved, by problems with cost, and was not completed until 1864, five years after his death.

In 1835 Brunel took on his most significant commission: he was appointed as engineer to the Great Western Railway (GWR), and over the next four years oversaw the construction of the London to Bristol line. He was also engineer for the Bristol and Exeter and South Devon Railways, which extended the London to Bristol line as far as Penzance by 1878. Brunel's work for the GWR was as innovative as the rest of his inventions. Not only did he make the railway so flat and fast that it became known as "Brunel's Billiard Table", but he also built bridges and tunnels along the route such as Maidenhead Bridge, with the flattest brick arches ever built, and Box Tunnel between Swindon and Bath. At two miles long, it was the longest railway tunnel in the world. To begin with, many passengers left the train at stations either side, preferring to ride over the hill in a carriage.

As well as the Clifton Suspension Bridge and the GWR, Brunel's other achievements included building three transatlantic passenger liners, the Great Eastern, Great Western and the SS Great Britain, which used iron for ship's hulls for the first time. He also built, in 1855, a wooden prefabricated hospital

to be shipped to the Crimean peninsula of the Black Sea, where Florence Nightingale was desperately campaigning for better medical care for soldiers fighting in the Crimean War. The hospital provided much improved levels of cleanliness; in eight months 1,331 patients were treated, and only 50 died.

Brunel's feats of engineering show a creative thinker with a streak of Gallic brio. He was also a workaholic insomniac who needed to be involved in every aspect of a project. He surveyed all 118 miles of the London to Bristol line himself, on foot or on horseback, and often worked all night on the plans for his projects. His single-mindedness is illustrated by the fact that his walking-stick, which at first glance appeared just like any other, could at the flick of his wrist unfurl to a length of 7ft ¼ inch, the width of his broad gauge railway track, to enable him to check that the navvies were digging the correct width. As his friend and colleague Daniel Gooch, who had worked with him on the GWR, put it:

> *One feature of Brunel's character, and it was one that gave him a great deal of extra and unnecessary work, was that he fancied no-one could do anything but himself*

Brunel found it hard to delegate to subordinates, and was not always able to cost a job accurately. He had a fine sense of the dramatic, and tended to choose the most striking solution to a problem rather than the most practical and cost-effective.

Brunel's heavy workload and intense approach to life (not to mention his habit of chain-smoking cigars) took its toll, and he died in 1859, aged 53. Daniel Gooch paid him this tribute:

> *I lost my oldest and best friend, a man with the greatest originality of thought and power of execution, bold in his plans but right. The commercial world thought him extravagant; but although he was so, great things are not done by those who sit down and count the cost of every thought and act.*

Brunel's most obvious legacy lies in his feats of engineering, such as the GWR, the Clifton Suspension Bridge and the SS Great Britain. These were staggering achievements, but it should also be remembered that he set the standard for many areas of civil engineering for the next two centuries, for example in the construction of railways and prefabricated buildings, and in ship-building. Finally his bravura designs for bridges, aqueducts and stations gave functional constructions an aesthetic beauty which was, for their time, revolutionary.

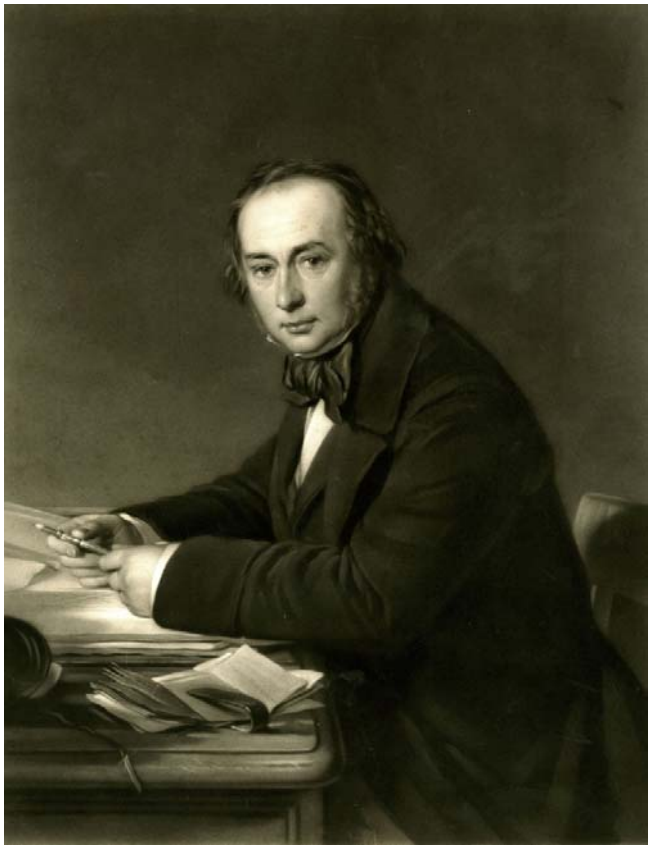


Image 1: Lithographed portrait of Brunel from a painting by John Callcott Horsley of 1857
(STEAM - Museum of the GWR, Swindon)

3. Historical Context: the Growth of Industrialisation

The nineteenth century was a time of massive social and economic upheaval in Britain. The population increased, and developments in agriculture such as enclosure of common land, and the mechanisation of some processes, coupled with the growth of industrial manufacture, led many people to move from rural areas to the towns. As more goods were produced, more transport was needed to move them around the country. The canal system, which had been spreading since the mid-eighteenth century, was not sufficient, and road transport was slow, unreliable and costly. Railways filled this gap, helped by the development of new methods of producing iron and steel for construction, and more efficient steam locomotives. As the railways developed, they in turn encouraged the growth of cities and the expansion of industry, and helped to foster the development of engineering skills for the newly industrialised economy.

The nineteenth century was a time of spectacular technological advances in manufacturing. The textile industry, for example, became rapidly mechanised as a result of James Hargreaves' (c1719-78) invention of the spinning jenny in the 1760s, and Richard Arkwright's (1732-92) water frame of the following decade. The power loom, which came into use in the 1820s, further increased

the industry's capacity for production. By 1830 the textile industry was second only to agriculture in the number of workers it employed.

One of the most important industries which developed during the Industrial Revolution, and which played a vital part in many of Brunel's schemes, was that of iron production. The development of the coke-fired blast furnace and Henry Cort's (1740-1800) puddling process helped to increase the rate of iron production. Henry Bessemer's (1812-98) invention of a converter in 1856 marked the start of bulk steelmaking, which helped to make general engineering the most important of the manufacturing industries.

Steam power was also an essential component of many of Brunel's achievements. From the early nineteenth century more and more powerful and more efficient steam engines were powering industry, following James Watt's (1736-1819) early improvements, replacing water power as a prime source.

4. Brunel and His Contemporaries

Brunel was one of a group of multi-disciplined engineers who came to prominence in the mid-nineteenth century, when engineering was attaining a newly professional status. The table at the bottom of this section lists the most important engineers, their dates and their major achievements. The group included: John Rennie senior and junior, who between them oversaw the construction of much of the canal system in the north of England, and built Waterloo and Southwark Bridges, and the London Docks; and Thomas Telford, remembered for the Menai Bridge and other iron bridges, and his work on the Ellesmere Canal with William Jessop, and Caledonian Canal as well as numerous roads. George Stephenson, who oversaw the construction of the Stockton to Darlington Railway and built the revolutionary steam locomotive "Rocket", was also significant, along with his son Robert, responsible for the London and Birmingham Railway, the High Level Bridge across the Tyne at Newcastle, and the Britannia Bridge which carried the Holyhead railway across the Menai Strait.

The development of railways is a common thread running through the work of these pioneering engineers. Experiments in railways and steam locomotives to run on them had been going on since the late eighteenth century. The first ever journey by steam locomotive took place in 1804, when Richard Trevithick's Penydarren locomotive travelled from Merthyr to Abercynon. The Stockton and Darlington Railway followed, opening in 1825. Stephenson's "Rocket" ran on the Liverpool and Manchester Railway (opened 1830). Stephenson and Brunel were professional rivals. Stephenson's trains ran on a gauge of 4 feet 8½ inches (1.44 metres), while Brunel, with his customary chutzpah and willingness to stand apart, decided that a broad gauge, of 7 feet ¼ inch (2.14 metres), would make for a smoother and faster journey. The Midland Railway ran on Stephenson's standard gauge, while the GWR favoured the broad gauge. Trains could not run from one gauge to another, so where the two systems met, all passengers, livestock and goods had to be physically transferred from one line to another. This first occurred at

Gloucester in 1845, and though a transfer shed had been built, with a platform between the two lines, the movement of passengers and goods between the two often proved chaotic (see picture).

Image 2: Changing trains at Gloucester c1855
(Gloucestershire Archives/Illustrated London News)

A Gauge Commission, set up by the government to investigate, decided in 1845 that Stephenson's standard gauge should triumph, though the GWR's broad gauge lingered on until 1892.

Aside from the arguments over the broad and standard gauges, railway travel was welcomed by the populace. As the railway system expanded, (5,120 miles of track had been laid by 1848), train travel became popular for day trips and holidays. From 1892 passenger services increased dramatically, and in 1904 the GWR inaugurated its Cornish Riviera Express, transporting thousands of holidaymakers to the beaches of the South West. The railways also provided employment; by 1847 around 250,000 navvies were working in the industry.

Queen Victoria was an early convert to train travel, making her first journey, from Slough to Paddington, on the GWR in June 1842. She was in safe hands; Daniel Gooch, the designer of the GWR's engines, was the driver, with Brunel himself on the footplate. The Queen enjoyed herself so much that she used the railway frequently to travel between Slough, Windsor and London. To make her trips more comfortable, the GWR built a Royal Saloon in 1844, and in 1897 spent £40,000 on six new carriages for the Royal Train. There is evidence that the Queen's enthusiasm for train travel did not extend to speed; she is said to have insisted that the Royal Train should not go beyond 40

miles per hour. As the GWR was renowned for the speed of its locomotives, this must have proved frustrating for the engine drivers!

Engineer	Major Achievements
William Jessop (1745-1814)	West India Dock Grand Junction Canal Cromford Canal Ellesmere Canal and Pontycysllte aqueduct with Thomas Telford (1793-1805) Remodelled Bristol harbour
John Rennie senior (1761-1821)	Albion Steam Flour Mill at Blackfriars (1784-88) Rochdale Canal (1804) London Docks (1805) Kennet and Avon Canal Glasgow, Paisley and Johnstone Canal Most of the canal system in the north of England Waterloo Bridge (1817) Southwark Bridge (1819)
John Rennie junior (1794-1874)	Plymouth breakwater (1811-48) London Bridge (1831)
George Stephenson (1781-1848)	Geordie safety lamp (1815) Hetton Colliery Railway (1820-22) Stockton and Darlington Railway (1822-25) 'Locomotion' locomotive (1825) Liverpool and Manchester Railway (1826-30) 'Rocket' locomotive (1829)
Robert Stephenson (1803-59)	London and Birmingham Railway (1838) High Level Bridge across the Tyne at Newcastle (1849) Britannia Bridge carrying Holyhead railway across the Menai Strait (1850)
Thomas Telford (1757-1834)	Ellesmere Canal and Pontycysllte aqueduct (1793-1805) with William Jessop Caledonian Canal (1822-47) Menai Bridge (1826) and other iron bridges Shropshire Canal Numerous roads

5. Brunel in Gloucestershire

Brunel was involved to some extent in most of Gloucestershire's major rail routes.

In 1833 he surveyed the line of the Birmingham & Gloucester and Bristol & Gloucester Railways, when engaged by the former's contractors Joseph & Charles Sturge of Birmingham. He undertook a second survey of the Bristol & Gloucester route in 1838 and was appointed the Railway's engineer in 1839. The line opened in 1844 and was built to Brunel's broad gauge, incorporating a section of earlier narrow gauge railway from Bristol to Westerleigh.

The Bristol & Gloucester and Birmingham & Gloucester Railways merged in 1845 to form the Bristol & Birmingham Railway which was in turn absorbed by the GWR's rival Midland Railway (MR) in 1846. The MR laid a standard gauge rail to Bristol in 1854 removing the need to change trains at Gloucester; broad gauge tracks were finally removed from the route in 1872.

Brunel's line to Gloucester included the ¾ mile (1.2 km) tunnel at Wickwar. He built two large brick bridges to carry the Roman road over the railway in the Vale of Berkeley. Brunel's' elegant road bridge of ashlar limestone over the railway at Frocester is Listed Grade II, but his early 50 foot (15.2 m) timber viaduct at Stonehouse was replaced. The Brunel-style station building at Charfield still exists (Listed Grade II) – the station is better known as the site of a disastrous railway accident of 1928 which killed 15 passengers. The similar Yate station was demolished following closure in 1965 but the goods shed remains (also Listed Grade II). Elsewhere evidence of the Bristol & Gloucester Railway's other four original stations can be seen only in the 'Tudor-gothic' style station houses at Stonehouse, Frocester, Berkeley Road (Listed Grade II) and Wickwar, which are in residential or commercial occupation.

Cheltenham had long been a strategic location where routes from London to South Wales and from the Midlands to the South West crossed. The Cheltenham & Great Western Union Railway provided a direct link to London via a connection to the GWR at Swindon. The line first opened in 1841 from Swindon to Kemble and Cirencester. The route from Kemble to Cheltenham via Stroud was completed in 1845 after take-over by the GWR, sharing the Bristol & Gloucester and Birmingham & Gloucester Railways' alignment from Standish northwards. The railway, which pierced the Cotswold Hills through the $1^{3}/_{8}$ mile (2.2 km) Sapperton Tunnel, opened new markets to coal mines in the Stroud Valley, where Brunel build other timber viaducts.

The original terminus station at Cirencester was designed by Brunel and built under the supervision of Charles Richardson. Today the Grade II Listed building stands isolated in the car park at Cirencester; the station closed in 1964. It is built of coursed squared limestone with a slate roof and has been described as an example of Gothic revival 'piled high with fanciful turrets, pinnacles and ornamentations'. Brunel's station at Stroud has been described

as '… less than satisfying. The frontage is long and low, in stone with few sparse Tudor motifs, angled chimney stacks, a central gable and a length of frilly valencing under the eaves at one side.' But is a complete GWR station with very little alteration and like the substantial goods shed is protected by Listing.

Brunel was engaged as the first engineer to the Oxford, Worcester & Wolverhampton Railway, known as the 'Old Worse and Worse'. Due to financial constraints he designed wooden station buildings rather than use the more appropriate Cotswold stone. Brunel resigned in 1851 to be replaced by John Fowler, but not until after the conflict at Mickleton Tunnel near Chipping Camden (See Section 8.4 below). The station at Adlestrop closed in 1966 but has been reserved a place in literary history by Edward Thomas's poem inspired when his train stopped there unexpectedly in 1898.

The South Wales Railway provided a route from Gloucester to Newport and Cardiff. The line opened first to a temporary station at Chepstow in 1851 until Brunel had completed his bridge over the River Wye the following year. The bridge was supported by large stressed wrought iron tubes, as later used in a modified form for Brunel's better known Royal Albert Bridge at Saltash of 1859. Chepstow Bridge was rebuilt in 1962 by the same local contractors, Fairfields that first constructed the bridge. Only the tubular supports of the original structure survive (Listed Grade II) – they were sunk using compressed air.

Image 3: The Bridge over the River Wye at Chepstow as originally built
(Elton Collection – Ironbridge Gorge Museum Trust AE185.318)

At Lydney the broad gauge South Wales line crossed the Severn & Wye Railway, built first as an early Forest of Dean tramway. Brunel had to undertake not to interfere with the latter's traffic for more than a day while the crossing was installed.

Brunel devoted much time investigating a suitable crossing-point on the River Severn to provide a more direct route west to Wales. The Bristol & South Wales Union Railway ran via a ferry from New Passage to Porteskewett, but didn't open until 1863, after Brunel's death. This was the principle route from Bristol to Wales until the present line through the Severn Tunnel opened in 1886, but little evidence remains of the railway.

Not all of Brunel's plans for railways in Gloucestershire came to fruition. At one stage he had suggested using part of the Bristol & Gloucestershire Railway for his GWR Bristol to London line, via Wick to Lanbridge east of Bath. His proposal for a South Wales & South of Ireland Railway from Stonehouse was opposed as it left out Gloucester and large towns in Monmouthshire.

Some railways in Gloucestershire established during Brunel's lifetime:

Railway	Incorporated	From / To	Opened	Notes
Bullo Pill	1809	Bullo / Bullo Pill	1812	Goods only; absorbed by Forest of Dean Railway 1826; closed 1958
Severn & Wye	1810	Lydney / Lydbrook	1812	First incorporated as Lydney & Lydbrook Railway 1809; operated as tramway until 1868; closed 1967; part now Dean Forest Railway since 1970
Birmingham & Gloucester	1836	Birmingham / Gloucester plus Ashchurch / Tewkesbury branch	1840	**IKB** First passenger railway in Gloucestershire; amalgamated with Bristol & Gloucester Railway 1845 as Bristol & Birmingham Railway; absorbed by Midland Railway 1846
Bristol & Gloucester	1839	Bristol / Gloucester	1844	**IKB** Linked to GWR line to London at Bristol; amalgamated with Birmingham & Gloucester Railway 1845 as Bristol & Birmingham Railway; absorbed by Midland Railway 1846; broad gauge until 1872.
Cheltenham & Great Western Union	1836	Swindon / Standish Kemble & Cirencester	1845	**IKB** Initially to Kemble & Cirencester 1841; absorbed by GWR 1843; gave direct route from Gloucester & Cheltenham to London via Stroud

Railway	Incorporated	From / To	Opened	Notes
Forest of Dean	1826	Bullo / Cinderford	1847	Opened as branch of South Wales Railway; closed 1967
Gloucester & Dean Forest	1846	Gloucester / Grange Court	1851	North-east section of South Wales Railway; absorbed by GWR 1874
South Wales	1845	Gloucester / Newport & Cardiff	1852	**IKB** Initially to Chepstow 1851 until construction of bridge over River Wye; absorbed by GWR 1863
Oxford, Worcester & Wolverhampton (OWWR)	1845	Oxford / Evesham	1853	**IKB** Absorbed by West Midland Railway 1860; then by GWR 1863
Hereford, Ross & Gloucester	1851	Grange Court / Ross-on-Wye	1855	Initially to Hopesbrook 1853; absorbed by GWR 1862; closed 1964
Dursley & Midland Joint		Coaley / Dursley	1856	Closed 1966
Coleford, Monmouth, Usk & Pontypool	1853	Pontypool / Wyesham	1856	Coleford was not reached until 1883; absorbed by GWR 1887; Coleford closed 1967
Banbury & Cheltenham	1860	Chipping Norton / Bourton-on-the-Water	1862	Known as Bourton-on-Water Railway; initially operated by OWWR; absorbed by GWR 1874; closed 1964
Bristol & South Wales Union	1857	Bristol / New Passage	1863	**IKB** Via ferry to Porteskewett; absorbed by GWR 1868; closed 1886
Forest of Dean Central	1856	Awre / Howbeach Colliery	1868	Goods only; absorbed by GWR 1923

IKB = Brunel involvement

6. Visiting Museums and Historic Sites

Museums and historic sites can be used to deliver a broad range of cross-curricula themes. It may be difficult for you to take your class out of school on a visit, but consider how many areas of the curriculum you could cover in one visit! Later in this pack you will find some ideas for specific Brunel-related activities you can do in the classroom, but here are just a few suggestions of the subjects you could cover by visiting a museum to look at their collections of objects, documentary sources and photographs:-

Foundation Skills

- Personal and social development; developing respect for their own and other's cultures
- Language communication and literacy; asking questions about who, why and where
- Maths; time

History

- Examine first-hand, real evidence
- Learn about time and chronology
- Compare things, materials and the ways they are used, in the past and now
- Think about how what we know about the past depends on the evidence that survives
- Look at how areas are affected

Geography

- Think about how the landscape changes over time, eg hedges disappearing
- How do man's actions alter the countryside? eg building railways

Science

- Find out about different materials, where they come from, properties and how they can be used
- How some objects change over time, eg the stone used for tunnels and bridges begins to weather

English

- Write labels for things in museums, develop trails round a museum or a historic site for different groups, eg families
- Use sources such as reference books, encyclopaedias and the Internet to find out more about the things in museums
- Develop new vocabulary

Maths

- Sort, count and classify objects in museums
- Make charts and graphs of numbers of objects

Art

- Provide inspiration for pupils' own work
- Find out about styles from the past, and from other cultures

PSHE

- Make a classroom museum and share responsibility for looking after it
- Discuss why museums collect the things they do
- Talk about how people look after objects

7. Classroom-based Activities

7.1 Plan a Railway in Your Playground: Geography, Mathematics, Design & Technology

- Design the route for a railway round your school grounds.
- Make a map of the area you want to use, including features such as classrooms, trees, paths, and showing where the ground rises or dips. If possible, you should make the map to scale (depending on the size of the area), so that you can work out how much track you will need. To measure the grounds, you could use a version of engineer's chains, which Brunel used to measure for the GWR. Engineer's chains were equal lengths of metal linked together with rings. To make your own version, start with a ball of string, then use a tape measure to make knots at 0.5 metre intervals. You can now use this to measure your route.
- Now make more precise measurements and draw a scale map. Now you need to decide the route your railway is going to take. You need to consider where you want the train to stop, for example at each classroom, at the play area. And what features will you have to avoid, such as trees? If there are humps in the grassy areas, are they too steep for the train to go up easily? If so, you might need to build a tunnel or construct a cutting.
- Finally, give your railway a name.
- You could also design a timetable, perhaps using desktop publishing software, making sure that you have enough trains running at busy times of the day, such as lunchtime and going-home time.

This activity maps onto the following areas of the National Curriculum:

- **Geography**
  - **1 Undertaking Geographical Enquiry (1a Asking geographical questions)**
  - **2 Developing Geographical Skills (2b Using appropriate fieldwork techniques, 2c Using maps and plans, 2e Drawing maps and plans, 2g Decision-making skills)**

- **Mathematics**
  - **Solving numerical problems**
  - **Written methods**
  - **Using and applying number**
  - **Communicating**

- **Design & Technology**
  - **1 Developing, planning and communicating ideas**

7.2 Design a Railway Uniform: Design & Technology, History

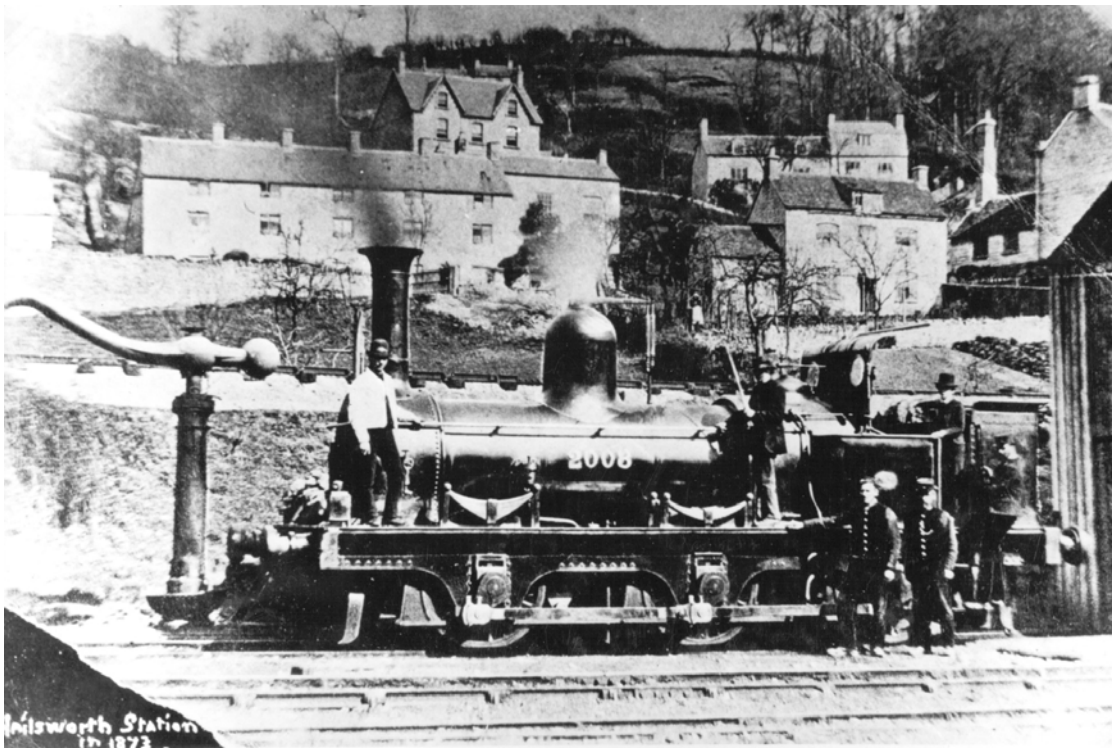


Image 4: Steam locomotive and engine crew at Nailsworth station in 1873
(Gloucestershire Archives)

This photograph shows the engine-driver (the man wearing the white coat standing on the engine at the left), the fireman and guards. It took many years to become an engine-driver. Most drivers started out cleaning engines, and had to progress through the "links", (the ranks of railway workers) before they could become drivers. Often men did not reach the Top Link (ie driving express passenger trains) until they were in their fifties. For this reason men were very proud to be engine-drivers.

- Discuss why you think the engine-driver is dressed so differently from the other men. Is white a good colour for an engine-driver to wear?
- Design a new uniform for the driver, fireman, ticket-collectors and porters to wear. Remember that you need to show the differences between them. You can use modern materials.

This activity maps onto the following areas of the National Curriculum:

1.1. Design & Technology

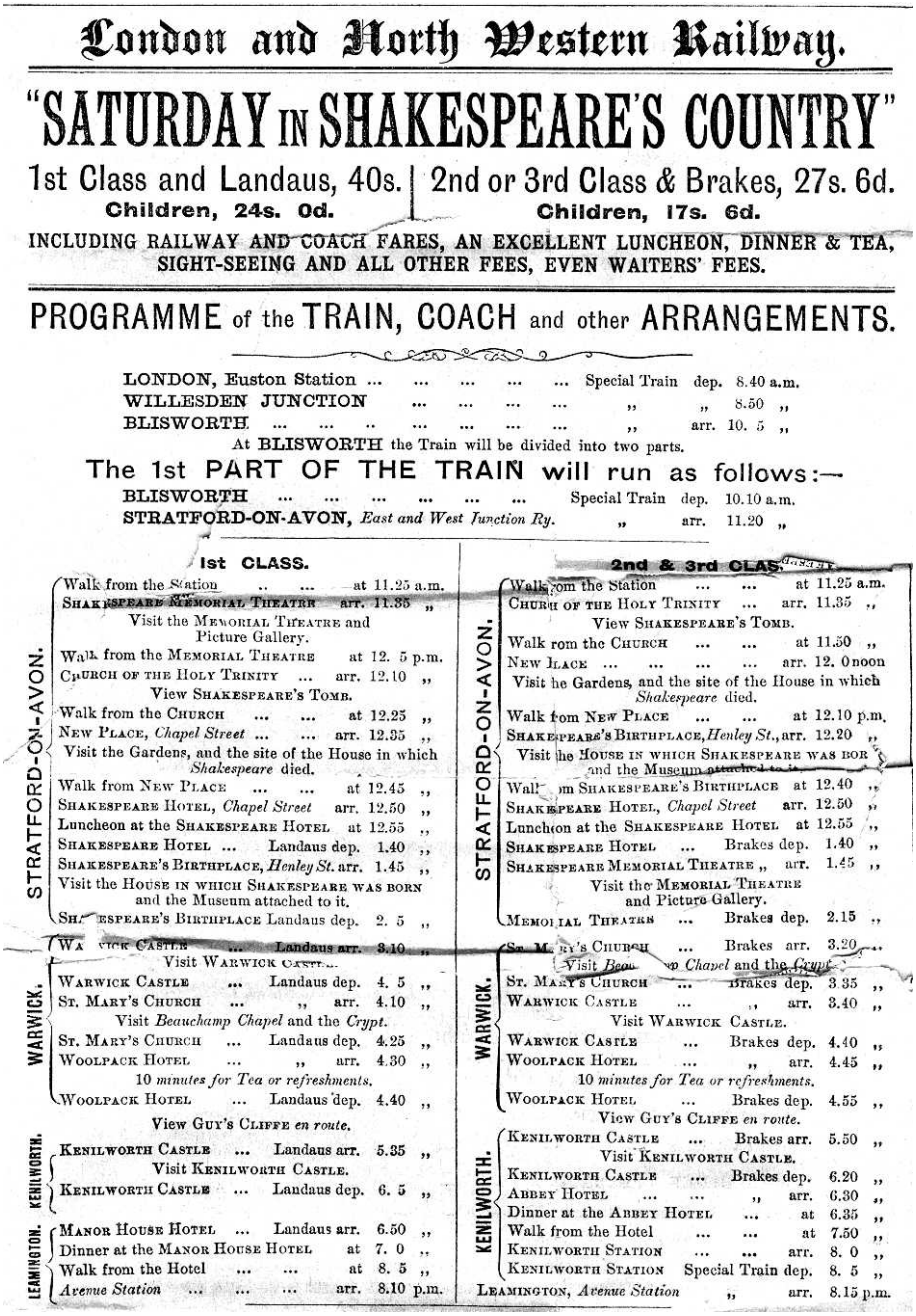
1.1.1. 1 Developing, planning and communicating ideas (1b Develop ideas and explain them clearly, putting together a list of what they want their design to achieve, 1c Plan what you have to do, 1d Communicate design ideas)

1.1.2. 4 Knowledge and understanding of materials and components (4a How working characteristics of materials affect the ways in which they are used)

1.2. History

- **4 Historical Enquiry (4a How to find out about events, people and changes from a wide range of sources)**

7.3 Day-Trips Then and Now: Design & Technology, History, Mathematics



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LONDON, Euston Station ... ... Special Train dep. 8.40 a.m.
WILLESDEN JUNCTION ... ... ,, ,, 8.50 ,,
BLISWORTH ... ... ,, arr. 10. 5 ,,

At BLISWORTH the Train will be divided into two parts.

The 1st PART OF THE TRAIN will run as follows:—

BLISWORTH ... ... Special Train dep. 10.10 a.m.
STRATFORD-ON-AVON, *East and West Junction Ry.* ,, arr. 11.20 ,,

	1st CLASS.	2nd & 3rd CLASS.
STRATFORD-ON-AVON.	Walk from the Station .. ... at 11.25 a.m. SHAKESPEARE MEMORIAL THEATRE arr. 11.35 ,, Visit the MEMORIAL THEATRE and Picture Gallery. Walk from the MEMORIAL THEATRE at 12. 5 p.m. CHURCH OF THE HOLY TRINITY ... arr. 12.10 ,, View SHAKESPEARE'S TOMB. Walk from the CHURCH ... ... at 12.25 ,, NEW PLACE, *Chapel Street* ... ... arr. 12.35 ,, Visit the Gardens, and the site of the House in which *Shakespeare* died. Walk from NEW PLACE ... ... at 12.45 ,, SHAKESPEARE HOTEL, *Chapel Street* arr. 12.50 ,, Luncheon at the SHAKESPEARE HOTEL at 12.55 ,, SHAKESPEARE HOTEL ... Landaus dep. 1.40 ,, SHAKESPEARE'S BIRTHPLACE, *Henley St.* arr. 1.45 ,, Visit the HOUSE IN WHICH SHAKESPEARE WAS BORN and the Museum attached to it. SHAKESPEARE'S BIRTHPLACE Landaus dep. 2. 5 ,,	Walk from the Station ... ... at 11.25 a.m. CHURCH OF THE HOLY TRINITY ... arr. 11.35 ,, View SHAKESPEARE'S TOMB. Walk from the CHURCH ... ... at 11.50 ,, NEW PLACE ... ... arr. 12. 0 noon Visit the Gardens, and the site of the House in which *Shakespeare* died. Walk from NEW PLACE ... ... at 12.10 p.m. SHAKESPEARE'S BIRTHPLACE, *Henley St.*, arr. 12.20 ,, Visit the HOUSE IN WHICH SHAKESPEARE WAS BORN and the Museum attached to it. Walk from SHAKESPEARE'S BIRTHPLACE at 12.40 ,, SHAKESPEARE HOTEL, *Chapel Street* arr. 12.50 ,, Luncheon at the SHAKESPEARE HOTEL at 12.55 ,, SHAKESPEARE HOTEL ... Brakes dep. 1.40 ,, SHAKESPEARE MEMORIAL THEATRE ,, arr. 1.45 ,, Visit the MEMORIAL THEATRE and Picture Gallery. MEMORIAL THEATRE ... Brakes dep. 2.15 ,,
WARWICK.	WARWICK CASTLE ... Landaus arr. 3.10 ,, Visit WARWICK CASTLE. WARWICK CASTLE ... Landaus dep. 4. 5 ,, ST. MARY'S CHURCH ... ,, arr. 4.10 ,, Visit *Beauchamp Chapel* and the *Crypt*. ST. MARY'S CHURCH ... Landaus dep. 4.25 ,, WOOLPACK HOTEL ... ,, arr. 4.30 ,, 10 *minutes for Tea or refreshments.* WOOLPACK HOTEL ... Landaus dep. 4.40 ,, View GUY'S CLIFFE *en route.*	ST. MARY'S CHURCH ... Brakes dep. 3.35 ,, WARWICK CASTLE ... ,, arr. 3.40 ,, Visit WARWICK CASTLE. WARWICK CASTLE ... Brakes dep. 4.40 ,, WOOLPACK HOTEL ... ,, arr. 4.45 ,, 10 *minutes for Tea or refreshments.* WOOLPACK HOTEL ... Brakes dep. 4.55 ,, View GUY'S CLIFFE *en route.*
KENILWORTH.	KENILWORTH CASTLE ... Landaus arr. 5.35 ,, Visit KENILWORTH CASTLE. KENILWORTH CASTLE ... Landaus dep. 6. 5 ,,	KENILWORTH CASTLE ... Brakes arr. 5.50 ,, Visit KENILWORTH CASTLE. KENILWORTH CASTLE ... Brakes dep. 6.20 ,, ABBEY HOTEL ... ... ,, arr. 6.30 ,, Dinner at the ABBEY HOTEL ... at 6.35 ,, Walk from the Hotel ... ... at 7.50 ,, KENILWORTH STATION ... ... arr. 8. 0 ,, KENILWORTH STATION Special Train dep. 8. 5 ,,
LEAMINGTON.	MANOR HOUSE HOTEL ... Landaus arr. 6.50 ,, Dinner at the MANOR HOUSE HOTEL at 7. 0 ,, Walk from the Hotel ... ... at 8. 5 ,, *Avenue Station* ... ... arr. 8.10 p.m.	LEAMINGTON, *Avenue Station* ,, arr. 8.15 p.m.

Image 5: London & North Western Railway poster
(Gloucestershire Archives)

This is a poster for a day-trip from London to Stratford-on-Avon in the late nineteenth century. Notice that there are three different classes of ticket: first, second and third. Each is priced differently and the more expensive the ticket, the more luxurious the transport; first class ticket holders travel by landau, a very comfortable, covered coach, while third class passengers go in brakes, which were open carriages, less well sprung and therefore less comfortable than landaus.

- Discuss the differences between first, second and third class travel. Do such differences exist nowadays? The itinerary for each class also varies. Why would this be?
- Now examine the itinerary, and work out how long the group had to spend at each venue, for example the first class travellers had one hour and five minutes to spend at Warwick Castle.
- Ask the class to work out an itinerary by train for a day-trip they would like to make, to a zoo, amusement park or special event such as a football match. Where will their train need to stop? You could use train timetables or websites (www.railtrack.com) to calculate the times needed for the journey and the cost of the tickets.
- Now design a poster to advertise the trip, making sure that it is as attractive as possible, and that it contains all the relevant information.

This activity maps onto the following areas of the National Curriculum:

- **Design & Technology**
  - **1 Developing, planning and communicating ideas (1a Generate ideas for products after thinking about who will use them and what they will be used for, using information from a number of sources, including ICT-based sources, 1b Develop ideas and explain them clearly, putting together a list of what they want their design to achieve)**
  - **2 Working with tools, equipment, materials and components (2a Select appropriate tools and techniques for making their product, 2d Measure, mark out, cut and shape a range of materials, and assemble, join and combine components and materials accurately)**

- **History**
  - **1 Chronological understanding (1a Place events, people and changes into correct periods of time)**
  - **2 Knowledge and understanding of events, people and changes in the past (2a Learn about characteristic features of the periods and societies studied, including the ideas, beliefs, attitudes and experiences of men, women and children in the past)**
  - **4 Historical enquiry (4a How to find out about the events, people and changes studied from an appropriate range of**

sources of information such as pictures and photographs, artefacts)

- **Mathematics**
  - **1 Using and applying number**
  - **2 Numbers and the number system (2d Fractions, percentages and ratio, decimals)**
  - **4 Solving numerical problems**

7.4 The Battle of Mickleton Tunnel: English

In July 1851 Brunel was involved in the last pitched battle ever fought between private armies on English soil: the Battle of Mickleton Tunnel. Mickleton was a village on the Oxford, Worcester and Wolverhampton Railway, for which Brunel was the engineer. The contractor building the railway, Marchant, was not working as fast as Brunel wished, and the company wanted to take possession of the works and appoint a new contractor. Marchant resisted, and whenever the new contractors approached, Marchant's men threatened them with clubs. Brunel grew impatient and took matters into his own hands. As *Berrow's Worcester Journal* reported:-

> "On Sunday afternoon, the resident contractor, Mr Marchant, discovered that a large body of men, at Warwick, under the control of the Company, were busily engaged in preparing, secretly, to march upon the works at Mickleton, under the shade of night, hoping to catch the contractors by surprise"

On Friday 20 July 1851 Brunel arrived at the Tunnel, riding a white horse and commanding an army of navvies. Police and magistrates were also present, having been warned that there might be trouble. Brunel retreated, only to return on Saturday. The law was still there, and after a magistrate read the Riot Act twice, Brunel and his men retreated again. Brunel spent Sunday gathering reinforcements; navvies were summoned from the GWR and the Birmingham and Oxford Railway, and all through Sunday night gangs of them woke the villages they marched through on their way to Mickleton. By 3am on Monday 23 July, Brunel was ready to attack again. Mounted on his white horse, he led his army of 2,000 navvies to the Tunnel. In fact there was very little fighting, though several men were injured and one had his little finger bitten off. Perhaps the sight of Brunel and his army was too intimidating; perhaps it was the presence of the police, magistrates and the Gloucester Artillery that weakened Marchant's resolve. Whatever the reason, Marchant surrendered to Brunel, and Mickleton Tunnel was finally completed in 1852.

- Discuss the reasons for the Battle.
- Divide the class into three groups: the police and magistrates; Brunel's men; Marchant's men
- Give each group time to prepare a short speech about why they behaved the way they did. One member of the group could take

notes, another could write up the speech, and a third could deliver it to the rest of the class
- The class could vote for the group whom they consider has the best argument
- Alternatively, let each pupil write an account of what it felt like to be involved in the Battle; they could choose to be a policeman, a magistrate, a navvy on either side, or Brunel himself.

This activity maps onto the following areas of the National Curriculum:

- **English**
  - **1 Speaking (1a Use vocabulary and syntax that enables them to communicate more complex meanings, 1b Gain and maintain the interest and response of different audiences [for example, by exaggeration, humour, varying pace and using persuasive language to achieve particular effects], 1c Choose material that is relevant to the topic and to the listeners, 1d Show clear shape and organisation with an introduction and an ending)**
    - **3 Group discussion and interaction (3a Make contributions relevant to the topic and take turns in discussion, 3b Vary contributions to suit the activity and purpose, including exploratory and tentative comments where ideas are being collected together, and reasoned, evaluative comments as discussion moves to conclusions or actions, 3c Qualify or justify what they think after listening to others' questions or accounts, 3d Deal politely with opposing points of view and enable discussion to move on, 3e Take up and sustain different roles, adapting them to suit the situation, including chair, scribe and spokesperson, 3f Use different ways to help the group move forward, including summarising the main points, reviewing what has been said, clarifying, drawing others in, reaching agreement, considering alternatives and anticipating consequences)**
    - **4 Drama (4a Create, adapt and sustain different roles, individually and in groups, 4b Use character, action and narrative to convey story, themes, emotions, ideas in plays they devise and script, 4c Use dramatic techniques to explore characters and issues [for example, hot seating, flashback], 4d Evaluate how they and others have contributed to the overall effectiveness of performances)**

8. Timeline

Year	Brunel's life and work	Key events in Britain	Key events in science and engineering
1806	Brunel born 9 April at Portsea	First Trooping the Colour ceremony takes place at Horseguards' Parade	Thomas Telford's iron aqueduct opens on Ellesmere Canal
1825	Work begins on the Thames Tunnel (opens 1843)	Children under 16 not allowed to work more than 12 hours a day in cotton mills and factories	Stockton & Darlington Railway opens Work begins on Telford's Birmingham & Liverpool Canal
1829	Enters competition to design Clifton Suspension Bridge	Peel founds Metropolitan Police. Catholic Emancipation Act allows Roman Catholics to hold public office	Stephenson's Rocket undergoes trials
1830	Elected Fellow of the Royal Society	William IV accedes to the throne. Swing Riots take place.	Liverpool & Manchester Railway opens
1831	Designs for Clifton Suspension Bridge accepted Enlists as special constable during Bristol Riots	Captain Swing riots	Faraday demonstrates electro-magnetic induction, Darwin begins voyage on Beagle
1832		First Reform Act passed, gives middle class men over 21 the right to vote	Improved method for making sheet glass invented
1833	Made chief engineer for Great Western Railway	First Factory Act bans employment of children under 9. Slavery abolished in British Empire	Pattinson invents process to separate silver from lead
1834		Tolpuddle Martyrs sentenced to transportation. National education system introduced, Poor Law Amendment Act	Babbage develops analytic engine, an early computer
1835	GWR accept Brunel's broad gauge proposal. Appointed engineer for Cheltenham & Great Western Union, Bristol & Exeter, Bristol & Gloucester and Merthyr & Cardiff railways		Fox Talbot takes negative photograph at Lacock Abbey
1836	Appointed engineer of Great Western Steam Ship Company. Marries Mary Horsley. Work starts on SS Great Western and Box Tunnel	Compulsory registration of births, marriages and deaths	The Beagle (Darwin's ship) returns to Britain. Ericsson patents screw propeller
1837	Daniel Gooch made GWR Locomotive Superintendent	Accession of Queen Victoria. Anti-Corn Law Association established	Electric telegraph developed

Year	Brunel's life and work	Key events in Britain	Key events in science and engineering
1838	SS Great Western's maiden voyage. Paddington to Maidenhead section of GWR opens. Work begins on Bristol Temple Meads Station.	First Chartist petition	Completion of London to Birmingham Railway Line
1839	Maidenhead Bridge opens and line extended to Twyford. Construction begins on SS Great Britain	Chartist riots	Naismith's steam hammer invented, watermark patent registered
1840	GWR opens from Bristol to Bath	First teachers' training college opens, Penny Post started	Electro-plating invented
1841	Box Tunnel and Bristol Temple Meads Station open. London to Bristol route opens. GWR associate company Bristol & Exeter Railway formed.	Mudie's Lending Library opens London	Whitworth's standardised screw thread invented, shipbuilding yards founded at Govan
1842	Bristol to Taunton section of Bristol & Exeter Railway opens	Plug Plots	Bessemer's typesetting machine
1843	Swindon locomotive works open, also Thames Tunnel. SS Great Britain launched	*News of the World* published for the first time,	Nelson's column erected in Trafalgar Square
1844	Appointed engineer to South Wales, Wilts, Somerset & Weymouth, Oxford, Worcester & Wolverhampton, Berks & Hants, Oxford & Rugby, Monmouth & Hereford railways	Factory Act restricts working hours of women and children. Co-operative Society founded	Reinforced concrete patented. Morse sends first telegraph message.
1845	Maiden voyage of SS Great Britain	Lunacy Act	Compound steam engine invented by William McNaught
1847	Atmospheric railway opens on Exeter to Teignmouth line	British Museum opens	Chloroform first used as anaesthetic
1851	Battle of Mickleton Tunnel	Great Exhibition in Hyde Park	Telegraph cable laid between France and Britain. Singer invents sewing machine
1852	SS Great Britain makes the first regular steamship voyages to Australia	Great Ormond Street Children's Hospital opens	King's Cross Station built
1854	Paddington Station opens	Chartist movement comes to an end, Crimean War begins	Coleman's factory opens Norwich, Fowler's steam plough invented
1855	Designs prefabricated hospital for the Crimea	Florence Nightingale initiates nursing reforms	Bunsen invents the Bunsen burner
1856		British Medical Association formed	Bessemer's converter for steel production introduced
1858	SS Great Eastern launched	Cheltenham Ladies' College opens	Hoffman's kiln introduced
1859	Royal Albert Bridge at Saltash opens Brunel dies 15 September	Big Ben first begins to tell the time	Darwin's "Origin of Species" published. Robert Stephenson dies. Steam-roller invented

Year	Brunel's life and work	Key events in Britain	Key events in science and engineering
1864	Clifton Suspension Bridge opens		Louis Pasteur invents pasteurisation of milk

9. Glossary

Aqueduct: A structure for carrying a canal over a river, road or valley.

Bessemer's converter (invented by Henry Bessemer between 1853 and 1856): molten pig-iron could be turned directly into steel by blowing air through it in a converter. This cut out the wrought-iron stage and dramatically reduced the cost of producing steel.

Coke-fired Blast Furnace: A furnace in which iron is smelted suing iron ore, limestone as a flux and coke (originally charcoal) first developed by the Coalbrookdale Company from 1709

Coursed: Building materials, eg stone or brick, used as a horizontal layer

Cutting: Valley created through a hill for a railway track as an alternative to a tunnel.

Industrial Revolution: A cluster of events which turned Britain from an agricultural, rural economy into an urban, manufacturing nation. Factors included the improvements in steam power and increasing factory production.

Spinning Jenny (invented by James Hargreaves in 1764): A machine which used eight spindles onto which the thread was spun from a corresponding set of rovings. By turning a single wheel, the operator could now spin eight threads at once. Later, improvements were made that enabled the number to be increased to eighty. The thread that the machine produced was coarse and lacked strength, making it suitable only for the filling of weft, the threads woven across the warp.

Power loom (first invented in1784 by Edmund Cartwright, further developed by William Horrocks in 1802): Driven by steam engines, the loom performed mechanically all those operations previously done by weavers. Horrocks's improved power loom featured a more effective way of winding the woven cloth onto a beam at the back of the loom.

Puddling (invented by Henry Cort between 1783 and 1785): Crude pig iron was decarbonised in a reverberatory furnace, where carbon from the iron ore combined with oxygen from the coke to produce a malleable or wrought iron - as opposed to cast iron - that could be rolled out in a rolling mill.

Viaduct: A bridge, usually resting on raised arches, carrying a railway across low-lying land or water.

Water Frame (invented by Richard Arkwright in the 1760s): A machine, driven by the power of a water wheel, which involved three sets of paired rollers that turned at different speeds. While these rollers produced yarn of the correct thickness, a set of spindles twisted the fibres firmly together.

10. Further Resources

10.1 Brunel Exhibition

The exhibition highlights the achievements and legacy in Gloucestershire of Brunel and his contemporaries, and features material in the county's museums and archives. Attention is drawn to surviving civil engineering structures and the development of the railway network. This exhibition is the result of a partnership project involving museums, archives and libraries in Gloucestershire, co-ordinated by Gloucestershire Archives, and has been supported by MLA South West. The production of the exhibition panels was kindly sponsored by Image Design. The exhibition will be touring museums, libraries and archives during 2006 and covers the following topics:

- Travel Before The Railways
- Brunel The Man
- Brunel In Gloucestershire
- Victorian Engineers
- Battle Of The Gauges
- A Transport Revolution
- An Engineering Legacy
- Finding Out More

10.2 Teaching Resources

The following websites provide links to teaching resources in Gloucestershire:

Museums for Schools: a teachers' guide to museum and heritage resources in Gloucestershire:
http://www.glos.gov.uk/museumsforschools

Library Services for Education: information on resources:
http://www.gloucestershire.gov.uk/lseweb

10.3 Museums and Heritage Sites

The following museums, archives and heritage sites in historic Gloucestershire material have material relating to Victorian engineering, industrial, travel and transport in their collections:-

Cheltenham Art Gallery & Museum
http://www.cheltenham.artgallery.museum/
Tel: 01242 237431

Clearwell Caves & Ancient Iron Mines
http://www.clearwellcaves.com/
Tel: 01594 832535

Corinium Museum, Cirencester
http://www.cotswold.gov.uk/nqcontent.cfm?a_id=1569&tt=cotswold
Tel: 01285 655611

Cotswold Motoring Museum, Bourton-on-the-Water
http://www.cotswold-motor-museum.com/
Tel: 01451 821255

Dean Heritage Centre, Soudley
http://www.deanheritagemuseum.com/
Tel: 01594 822170

Dursley Heritage Centre
Tel: 01453 542953

Gloucester Folk Museum
http://www.gloucester.gov.uk/Content.aspx?urn=1397
Tel: 01452 396467

Great Western Railway Museum, Coleford Tel: 01594 833569

Hopewell Colliery Museum, Cannop
http://www.hopewellcoalmine.co.uk/
Tel: 01594 810706

Kingswood Heritage Museum, Warmley Tel: 0117 932 4638 / 0117 967 5711

Museum in the Park, Stroud
http://www.stroud.gov.uk/docs/museum/museum.asp?did=new_mus_home
Tel: 01453 763394

National Waterways Museum, Gloucester
http://www.nwm.org.uk/
Tel: 01452 318200

Tewkesbury Museum
http://www.tewkesbury.biz/museum/
Tel: 01684 292901

Thornbury Museum
http://www.thornburymuseum.org.uk/
Tel: 01454 857774

Winchcombe Railway Museum Tel: 01242 620641

Wotton-under-Edge Heritage Centre
http://www.zkrational.com/heritagecentre_web/index.html
Tel: 01453 521541

10.4 Archives

Gloucestershire Archives, Gloucester
http://www.gloucestershire.gov.uk/index.cfm?articleID=1348
Tel: 01452 425295

Brunel items at Gloucestershire Archives include:

- Letter from Brunel to Edward Leader Williams, engineer to the Severn Commission 1844 (D2460/2/3/3/1)
- Minutes of Board of Directors of Cheltenham & Great Western Union Railway 1836-1843 (D3798/5 - includes Brunel's appointment as engineer in 1836)
- Sets of plans of railways submitted to the Quarter Sessions in Gloucestershire for which Brunel was the submitting engineer 1834-1856
- Letter mentioning Brunel walking 'proposed rail road along this Stroud valley' (TS234)
- Evidence of Brunel, Stephenson and Locke on 'gauge war' 1847 (J14.35GS)
- Account of the Battle of Mickleton (B743/36620GS)

University of Gloucestershire Archives, Cheltenham
http://www.glos.ac.uk/departments/lis/archives/index.cfm
Tel: 01242 543496

10.5 Heritage Railways

The spirit of the vintage steam railway lives on at several nearby sites:

Avon Valley Railway, Bitton
http://www.avonvalleyrailway.org/
Tel: 0117 932 5538

Dean Forest Railway and Museum, Norchard, Lydney
http://www.deanforestrailway.co.uk/
Tel: 01594 845840

Gloucestershire Warwickshire Railway, Toddington
http://www.gwsr.com/
Tel: 01242 621405

Perrygrove Railway, Coleford
http://www.perrygrove.co.uk/
Tel: 01594 834991

10.6 Libraries

Libraries throughout Gloucestershire can provide material on Brunel and related subjects; you can also search the Local Studies Catalogue on line at http://locate.gloucestershire.gov.uk/scripts/WEBC.EXE/cairstl/start

The following books may be helpful:

Brunel: the great engineer, Tim Bryan, Ian Allan, 1999

Brunel: the life and times of Isambard Kingdom Brunel, Angus Buchanan, Hambledon and London, 2001

Brunel: the man who built the world, Steven Brindle, Weidenfeld & Nicolson, 2005

Brunel's Broad Gauge Railway: commemorating the centenary of the GWR's gauge conversion, Christopher Awdry, Oxford Publishing Co., 1992

Brunel's Didcot: Great Western Railway to Great Western Society, Jack Gardner, Runpast, 1996

Gloucestershire Railway Stations, Mike Oakley, Dovecote Press, 2003

Isambard Kingdom Brunel: engineering knight-errant, Adrian Vaughan, John Murray, 1993

Men of iron: Brunel, Stephenson and the inventions that shaped the modern world, Sally Dugan, Macmillan, 2003 & Pan, 2005

The Bristol and Gloucester railway and the Avon and Gloucestershire Railway, Colin C Maggs, Oakwood Press, 1992

The Foundation of Brunel's Great Western Railway, Andre Gren, Silver Link, 2003

The Great Brunel, Chris Morris, Tanners Yard, 2005

The Iron Ship: the story of Brunel's SS Great Britain, Ewan Corlett, Conway Maritime, 1990

The Ocean Railway: Isambard Kingdom Brunel, Samuel Cunard and the revolutionary world of the great Atlantic steamships, Stephen Fox, HarperCollins, 2003 & Harper Perennial, 2004

Victorian Engineering, L.T.C. Rolt, Allen Lane, 1970

Wonders of Victorian engineering: an illustrated excursion, Allen Andrews, Jupiter Books, 1978

10.7 Elsewhere in the South West

Significant museum collections, archives and sites elsewhere in the south-west:-

- Bristol Record Office http://www.bristol-city.gov.uk/ccm/content/Leisure-Culture/Local-History-Heritage/Bristol-Record-Office-pages/bristol-record-office.en
- University of Bristol Brunel Collection http://www.bristol.ac.uk/is/library/collections/specialcollections/brunel.html
- British Empire and Commonwealth Museum, housed in Brunel's original Temple Meads Station, Bristol http://www.empiremuseum.co.uk/
- Clifton Suspension Bridge, Bristol http://www.clifton-suspension-bridge.org.uk/
- SS Great Britain, Bristol http://www.ssgreatbritain.org/
- Bath Spa Railway Station
- Sydney Gardens, Bath
- Railway Village and Works, Swindon
- STEAM - Museum of the Great Western Railway, Swindon http://www.steam-museum.org.uk/
- Box Tunnel, near Bath
- West Somerset Railway, Minehead http://www.west-somerset-railway.co.uk/
- Royal Albert Bridge and Saltash Station, Tamar
- Brunel Manor and Gardens, Torquay

10.8 Websites

The following websites contain useful information about Brunel and other engineers:-

www.brunel200.com
Details of all the activities planned for Brunel 200 can be found on this website. The site also provides information about Brunel, his projects, his contemporaries and successors, and their impact upon the modern world.

www.engineering-timelines.com
How engineering has shaped Britain.

www.bbc.co.uk/history/historic_figures/brunel_kingdom_isambard.shtml
I K Brunel and lots of links

www.greatbuildings.com/architects/Isambard_Kingdom_Brunel.html
A gateway to architecture around the world and across history documents a thousand buildings and hundreds of leading architects, with 3D models, photographic images and architectural drawings, commentaries,

bibliographies, web links, and more, for famous designers and structures of all kinds.

www.cottontimes.co.uk/brunelo.htm
Understanding the Industrial Revolution

11. Disclaimer

The information contained in this pack is believed to be accurate and reliable, but neither Gloucestershire County Council nor G&T Consulting Ltd can be held liable for any errors or omissions.

Please note that some of the sites referred to within the pack may not be fully accessible, no liability is accepted by Gloucestershire County Council or G&T Consulting Ltd for any loss or injury arising from field trips or visits.

12. Acknowledgements

We are grateful to the following organisations that have provided information or images for use in this pack:

Brunel 200
Gloucestershire Archives
Institute of Civil Engineers
Ironbridge Gorge Museum Trust
STEAM Museum of the Great Western Railway.

This pack has been researched and prepared for Gloucestershire County Council by Rhian Tritton and Steph Gillett (G&T Consulting Ltd). This project has been supported by MLA South West & MLA with funding from DCMS & DfES.