ABSTRACT

To achieve accreditation, engineering and technology programs throughout the United States must meet guidelines established by the Accreditation Board for Engineering and Technology (ABET). One of these requirements is that departments demonstrate that they provide students with an understanding of engineering in a broad, societal context. Examination of engineering history can be an essential element to this endeavor, because the development of modern theories and practices have diverse and complex evolutions which are often intimately intertwined with the development of societies themselves. Fluid mechanics is a key field of engineering, whose body of knowledge has had a significant influence on the design and operation of many products and systems over the centuries. Because of this, fluid mechanics coursework is often required for many engineering and technology majors and can, in fact, represent a key component to these programs. Toward these ends, this paper will discuss highlights from the history of fluid mechanics, and will provide several timelines that summarize key scientists, theories, events, equipment and machines. Considering fluid mechanics in this manner can achieve the goal of placing this branch of engineering in an appropriate societal context. It is always a challenge for educators to find useful and interesting material on history; therefore, a summary list of conventional and online resources will also be included. As such, this paper can be used as a resource for both engineering as well as history educators to supplement existing coursework.

Keywords
Curriculum Development, Engineering, Fluid Mechanics, History, Society, Technology

INTRODUCTION

As with many fields of modern scientific study, fluid mechanics is rooted in the history of humanity. Over time, as humans adapted and evolved, and their knowledge and skills increased, specific scientific and technological disciplines arose. Many modern conveniences which are now often taken for granted actually originated centuries ago, as have the theoretical foundations upon which they were developed. Throughout its history, fluid mechanics has been a field that has constantly advanced. Inquiry has progressed from trial and error, to formal experimentation, to mathematical theory. As with other engineering fields, it has now reached the point of scientific maturity, with most of the fundamentals clearly understood. As such, it has become a vital component for many engineering curricula. It is therefore a very useful exercise to examine the historical development of this discipline.
HISTORICAL DEVELOPMENTS

The development of the field of fluid mechanics, as with many other disciplines, is best examined within the context of the history of humans, which, for the purposes of this paper, can be conveniently categorized according to five major historical periods, including antiquity, Classical Civilization, the Middle Ages, the Renaissance through the Industrial Revolution, and the modern (i.e., post-Industrial Revolution). A brief, but thorough introduction to this history is provided by Munson et al. (2003). Tokaty (1971) provides a very comprehensive historical narrative.

During Antiquity (prior to approximately 500 B.C.), applications of fluid mechanics were solely for practical purposes, such as water distribution systems for the irrigation of agricultural crops. In fact, the cradles of civilization developed near river valleys primarily because of readily accessible supplies of water. Irrigation systems greatly expanded the surrounding lands and made them available for food cultivation. Additionally, early civilizations utilized water systems for the development of cities. For example, the Harrapan people of the Indus River Valley developed city-wide drainage systems to collect rainwater, and all houses had indoor plumbing and toilet facilities with connected sewer systems. Peoples during this time period also constructed crude rafts and boats, but over time developed highly sophisticated ships and barges. For instance, the Egyptians transported great quantities of massive stones on the Nile River in order to construct the pyramids.

During Classical Civilization, which lasted from approximately 500 B.C. to A.D. 500, and centered on the Greek and Roman Empires, many large-scale public works projects were constructed as cities reached new levels of complexity and style. Some of these projects included large bath houses, sewer systems, water distribution systems, and most prominently, the large aqueducts which transported water into Rome from distant water supplies such as rivers and lakes. During this time, many philosophers and mathematicians began theorizing and investigating the nature of objects, including fluids, in order to understand the world in which they lived.

The Middle Ages (approximately A.D. 500 to 1400) witnessed little development in the knowledge base of fluid mechanics, as was the case with most scientific pursuit during this time. On the other hand, waterwheels and windmills became quite prevalent during this time as means to power mills and other mechanical devices, and boat and ship construction evolved and progressed. At the end of the Middle Ages, European countries had developed advanced ocean-going vessels, and were about to embark upon global exploration.

During the Renaissance and Industrial Revolution, which lasted from approximately A.D. 1400 to 1900, a renewed interest in understanding and describing the nature of objects, including fluids, rapidly spread. Formal experimentation began to be used to facilitate these endeavors. Mathematical systems were developed to help describe the phenomena and the behaviors which were observed. Mathematic quantification thus led to the development of theory. During the Industrial Revolution, many devices were invented that utilized many of the principles that had been determined, especially machines that utilized fluid flow for the transfer of power.

During the modern age (approximately A.D. 1900 onward) the development of the airplane, two world wars, and the Cold War, not to mention the advent of the digital computer as well as computational fluid dynamics software, drove much of the developments in fluid mechanics, especially in the fields of aerodynamics and aeronautics.
Timelines are often used to summarize the progression of historical events. To make the rich history of the field fluid mechanics more accessible to both educators as well as students, the development of this discipline has thus been delineated according to key people who developed ideas and theories (Table 1), the ideas and theories themselves (Table 2), and significant inventions and events throughout history (Table 3).

**Table 1. Key people in the history of fluid mechanics.**

<table>
<thead>
<tr>
<th>Lifespan</th>
<th>Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>287 – 212</td>
<td>B.C. Archimedes</td>
</tr>
<tr>
<td>40 – 103</td>
<td>A.D. Sextus Julius Frontinus</td>
</tr>
<tr>
<td>1452 – 1519</td>
<td>Leonardo da Vinci</td>
</tr>
<tr>
<td>1564 – 1642</td>
<td>Galileo Galilei</td>
</tr>
<tr>
<td>1608 – 1647</td>
<td>Evangelista Torricelli</td>
</tr>
<tr>
<td>1623 – 1662</td>
<td>Blaise Pascal</td>
</tr>
<tr>
<td>1642 – 1727</td>
<td>Isaac Newton</td>
</tr>
<tr>
<td>1695 – 1771</td>
<td>Henry de Pitot</td>
</tr>
<tr>
<td>1700 – 1782</td>
<td>Daniel Bernoulli</td>
</tr>
<tr>
<td>1707 – 1783</td>
<td>Leonhard Euler</td>
</tr>
<tr>
<td>1717 – 1783</td>
<td>Jean le Rond d’Alembert</td>
</tr>
<tr>
<td>1718 – 1798</td>
<td>Antoine Chezy</td>
</tr>
<tr>
<td>1746 – 1822</td>
<td>Giovanni Battista Venturi</td>
</tr>
<tr>
<td>1785 – 1836</td>
<td>Louis Marie Henri Navier</td>
</tr>
<tr>
<td>1789 – 1857</td>
<td>Augustin Louis de Cauchy</td>
</tr>
<tr>
<td>1797 – 1884</td>
<td>Gotthilf Heinrich Ludwig Hagen</td>
</tr>
<tr>
<td>1799 – 1869</td>
<td>Jean Louis Poiseuille</td>
</tr>
<tr>
<td>1802 – 1870</td>
<td>Heinrich Magnus</td>
</tr>
<tr>
<td>1803 – 1858</td>
<td>Henri Philibert Gaspard Darcy</td>
</tr>
<tr>
<td>1806 – 1871</td>
<td>Julius Weisbach</td>
</tr>
<tr>
<td>1810 – 1879</td>
<td>William Froude</td>
</tr>
<tr>
<td>1816 – 1897</td>
<td>Robert Manning</td>
</tr>
<tr>
<td>1819 – 1903</td>
<td>George Gabriel Stokes</td>
</tr>
<tr>
<td>1829 – 1908</td>
<td>Lester Pelton</td>
</tr>
<tr>
<td>1838 – 1916</td>
<td>Ernst Mach</td>
</tr>
<tr>
<td>1842 – 1912</td>
<td>Osborne Reynolds</td>
</tr>
<tr>
<td>1842 – 1919</td>
<td>Lord Rayleigh (John William Strutt)</td>
</tr>
<tr>
<td>1850 – 1922</td>
<td>Vincenz Strouhal</td>
</tr>
<tr>
<td>1867 – 1940</td>
<td>Edgar Buckingham</td>
</tr>
<tr>
<td>1871 – 1951</td>
<td>Moritz Weber</td>
</tr>
<tr>
<td>1875 – 1953</td>
<td>Ludwig Prandtl</td>
</tr>
<tr>
<td>1880 – 1953</td>
<td>Lewis Ferry Moody</td>
</tr>
<tr>
<td>1881 – 1963</td>
<td>Theodor von Karman</td>
</tr>
<tr>
<td>1883 – 1970</td>
<td>Paul Richard Heinrich Blasius</td>
</tr>
</tbody>
</table>
### Table 2. Key theories in the history of fluid mechanics.

<table>
<thead>
<tr>
<th>Date</th>
<th>Theoretical Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>390 B.C.</td>
<td>Plato, a Greek philosopher, describes the origins of rivers as water escaping through holes in the ground</td>
</tr>
<tr>
<td>250</td>
<td>Archimedes publishes “Floating Bodies” in which he discusses the principles of buoyancy and hydrostatics</td>
</tr>
<tr>
<td>200</td>
<td>Chinese scholars discover that tides are connected to the lunar cycle</td>
</tr>
<tr>
<td>100</td>
<td>Greek philosopher Poseidonius discovers tides are connected to the lunar cycle</td>
</tr>
<tr>
<td>1643 A.D.</td>
<td>Evangelista Torricelli develops the relationship between pressure and velocity of fluids for free jets</td>
</tr>
<tr>
<td>1738</td>
<td>Daniel Bernoulli publishes “Hydrodynamica” which discusses the pressure and velocity of fluids, and delineates the Bernoulli equation</td>
</tr>
<tr>
<td>1768</td>
<td>Antoine Chezy develops relationships for open channel flow</td>
</tr>
<tr>
<td>1839</td>
<td>Gotthilf Heinrich Ludwig Hagen describes laminar flow properties</td>
</tr>
<tr>
<td>1840</td>
<td>Jean Louis Poiseuille describes laminar flow properties</td>
</tr>
<tr>
<td>1850</td>
<td>Rudolf Clausius develops kinetic theory of gases</td>
</tr>
<tr>
<td>1877</td>
<td>J. Boussinesq describes eddy viscosities in turbulent flows</td>
</tr>
<tr>
<td>1883</td>
<td>Osborne Reynolds describes the differences between laminar and turbulent pipe flow</td>
</tr>
<tr>
<td>1889</td>
<td>R. Manning develops a modified equation describing open channel flow</td>
</tr>
<tr>
<td>1891</td>
<td>Samuel Langley publishes “Experiments in Aerodynamics”</td>
</tr>
<tr>
<td>1895</td>
<td>Osborne Reynolds describes turbulent shear stresses</td>
</tr>
<tr>
<td>1904</td>
<td>Ludwig Prandtl develops solution to Navier-Stokes equations for boundary layer flow</td>
</tr>
<tr>
<td>1908</td>
<td>Paul Richard Heinrich Blasius develops solution to boundary layer equations for flow past a flat plate</td>
</tr>
<tr>
<td>1918</td>
<td>Ludwig Prandtl develops theory of flow over airplane wings</td>
</tr>
<tr>
<td>1919</td>
<td>Robert Goddard publishes “A Method of Reaching Extreme Altitudes”</td>
</tr>
<tr>
<td>1921</td>
<td>Hermann Oberth publishes “The Rocket into Interplanetary Space”</td>
</tr>
<tr>
<td>1933</td>
<td>J. Nikuradse describes relationships between pipe flow, friction factor, and Reynold’s Number</td>
</tr>
<tr>
<td>1944</td>
<td>L. Moody summarizes relationships between pipe flow, friction factor, and Reynold’s Number, and develops the Moody Chart</td>
</tr>
<tr>
<td>Date</td>
<td>Historical Development</td>
</tr>
<tr>
<td>------</td>
<td>------------------------</td>
</tr>
<tr>
<td>&gt; 3000 B.C.</td>
<td>Civilizations begin to develop when nomadic tribes settle near river valleys and begin cultivation of land</td>
</tr>
<tr>
<td>3000</td>
<td>Irrigation channels are used throughout Mesopotamia and Egypt. The Harrapans in the Indus River Valley build brick-lined cities, wells, and city-wide drainage systems. Most Harrapan homes have indoor toilets. Egyptians develop reed boats to travel throughout the Mediterranean.</td>
</tr>
<tr>
<td>2300</td>
<td>400 feet wide, 200 mile long Nahrawan Canal is constructed to connect the Tigris and Euphrates Rivers, used for navigation and irrigation.</td>
</tr>
<tr>
<td>2000</td>
<td>The shadoof, a pivoting pole with a water bucket at one end and a weight at the other, is developed in Mesopotamia to lift water for irrigation.</td>
</tr>
<tr>
<td>2000 – 1500</td>
<td>Egyptians develop irrigation systems utilizing water from the Nile River. Dams constructed in India to control water.</td>
</tr>
<tr>
<td>1820</td>
<td>A canal is dug between Lake Moeris and the Nile River to control flooding.</td>
</tr>
<tr>
<td>1700</td>
<td>Windmills are in use in Babylon, they are used to pump water for irrigation.</td>
</tr>
<tr>
<td>1500 – 1000</td>
<td>Shipbuilding arts reach advanced state in Mediterranean countries.</td>
</tr>
<tr>
<td>1450</td>
<td>200 feet long barges are constructed by the Egyptians to transport obelisks on the Nile River.</td>
</tr>
<tr>
<td>1400</td>
<td>Commercial shipping fleets operate around the Greek isles. The water clock (clepsydra) is in use in Egypt.</td>
</tr>
<tr>
<td>1300</td>
<td>20 feet high dam is constructed on the Orontes River in Syria by filling the river with rock.</td>
</tr>
<tr>
<td>1000 – 900</td>
<td>Subterranean water supply system constructed under Jerusalem.</td>
</tr>
<tr>
<td>800</td>
<td>Underground qanats (aqueducts) are drilled into Persian hills to find groundwater. Chinese invent a cart which is powered by steam.</td>
</tr>
<tr>
<td>750</td>
<td>50 feet high, 1970 feet long Marib dam is constructed in Yemen to provide water for irrigation, it operates for over 1000 years.</td>
</tr>
<tr>
<td>700</td>
<td>6 feet wide, 1750 feet long tunnel is constructed through solid rock to transport water from the Gihon Spring to Jerusalem. 80 feet long bireme boats are constructed by the Greeks.</td>
</tr>
<tr>
<td>700 – 600</td>
<td>Egyptian Pharaoh Necho constructs a canal between Nile River and Red Sea. Water clocks in use in Assyria.</td>
</tr>
<tr>
<td>691</td>
<td>66 feet wide, 50 mile long Jerwan aqueduct is constructed to transport water from the Greater Zab River to Nineveh in Assyria.</td>
</tr>
<tr>
<td>600 – 500</td>
<td>Construction of ¾-mile long water supply tunnel on Greek island of Samos. Theodorus of Samos develops the water level. Water supply system constructed in Athens, Greece, it consists of a well.</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
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<tr>
<td>------</td>
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</tr>
<tr>
<td>590</td>
<td>Rome’s drainage system is designed by its king Tarquinius Priscus Rome’s Great Sewer (Cloaca Maxima) is constructed by lining a river bed with stone</td>
</tr>
<tr>
<td>535</td>
<td>Samos Tunnel aqueduct is constructed on Samos island, it is 6 feet in diameter and 3300 feet long through solid rock</td>
</tr>
<tr>
<td>500 – 450</td>
<td>Many dams are constructed in India</td>
</tr>
<tr>
<td>475</td>
<td>Two-masted ships are in use around Mediterranean</td>
</tr>
<tr>
<td>400</td>
<td>First rain gauges used – in India Chinese first to burn oil as energy – for cooking of food</td>
</tr>
<tr>
<td>350</td>
<td>Cities in Greece and Sparta use underground pipes to carry hot air to heat buildings Construction begins on the southern portion of the Grand Canal Aristotle writes about primitive diving bells</td>
</tr>
<tr>
<td>347</td>
<td>Bamboo pipes are used in China to transport methane gas for lighting</td>
</tr>
<tr>
<td>312</td>
<td>Aqua Appia aqueduct, the first of several in Rome, is constructed to transport water 9.9 miles to Rome from the Sabine Hills</td>
</tr>
<tr>
<td>310</td>
<td>Chinese develop double-acting bellows to produce continuous air supply for smelting metals</td>
</tr>
<tr>
<td>300</td>
<td>The noria, which is a vertical water wheel with buckets, is developed in Mesopotamia to lift water for irrigation Rome develops an underground building heating system using piping for transport of hot air, similar to that in Sparta and Greece Wet rice is cultivated in Japan</td>
</tr>
<tr>
<td>250</td>
<td>Archimedes develops the Archimedes Screw to remove water from ships</td>
</tr>
<tr>
<td>245</td>
<td>Egyptian warships achieve 400 feet in length, and require 4000 rowers</td>
</tr>
<tr>
<td>211</td>
<td>Chinese drill first natural gas well, use bamboo pipes, 460 feet deep</td>
</tr>
<tr>
<td>200</td>
<td>Ox-powered water wheels are used to move water for irrigation Roman shipbuilders construct ships with three masts</td>
</tr>
<tr>
<td>159</td>
<td>The clepsydra (water clock) is first used in Rome</td>
</tr>
<tr>
<td>144</td>
<td>Aqua Marcia aqueduct in Rome is completed, it brings water 57 miles from the Anio River</td>
</tr>
<tr>
<td>125</td>
<td>Aqua Tepula aqueduct in Rome is completed, it brings water from the Alban Hills</td>
</tr>
<tr>
<td>100</td>
<td>Greeks install a weather vane on the Acropolis, and are the first to measure wind direction</td>
</tr>
<tr>
<td>85</td>
<td>Water wheels used in Greece to power mills</td>
</tr>
<tr>
<td>33</td>
<td>Aqua Julia aqueduct in Rome is completed</td>
</tr>
<tr>
<td>19</td>
<td>Aqua Virgo aqueduct constructed in Rome to supply public bath houses</td>
</tr>
<tr>
<td>2</td>
<td>20-mile Aqua Alsietina aqueduct constructed to bring water from Alsietinian Lake to the Naumachia basin in Rome for mock sea battles</td>
</tr>
<tr>
<td>30 A.D.</td>
<td>Water wheels are used in China to power bellows to forge agricultural equipment</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
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</tr>
<tr>
<td>700</td>
<td>Water wheels are used throughout Europe to power mills</td>
</tr>
<tr>
<td>900</td>
<td>Shipbuilding arts are developed by the Vikings in Scandinavia</td>
</tr>
<tr>
<td>1090</td>
<td>Water-driven mechanical clocks are developed in Beijing, China</td>
</tr>
<tr>
<td>1180</td>
<td>Windmills first used in Europe</td>
</tr>
<tr>
<td>1432</td>
<td>Portuguese have developed the caravel ocean-going ship</td>
</tr>
<tr>
<td></td>
<td>Gonzalo Cabral (Portugal) discovers the Azores islands</td>
</tr>
<tr>
<td></td>
<td>Beginning stages of European naval expeditions and expansion</td>
</tr>
<tr>
<td>1480</td>
<td>Leonardo da Vinci develops the first parachute</td>
</tr>
<tr>
<td>1490</td>
<td>Leonardo da Vinci investigates capillary movement of liquids in small tubes</td>
</tr>
<tr>
<td>1510</td>
<td>Leonardo da Vinci develops the first turbine water wheel</td>
</tr>
<tr>
<td>1512</td>
<td>British develop double-decked ships</td>
</tr>
<tr>
<td>1514</td>
<td>European ships reach China</td>
</tr>
<tr>
<td>1535</td>
<td>Diving bells in use for first time</td>
</tr>
<tr>
<td>1543</td>
<td>Blasco da Garay (Spain) designs the first steamboat</td>
</tr>
<tr>
<td>1582</td>
<td>City waterworks system is constructed in London</td>
</tr>
<tr>
<td>1592</td>
<td>Windmills are used to power saw mills in Holland</td>
</tr>
<tr>
<td>1596</td>
<td>Galileo Galilei develops the first thermometer</td>
</tr>
<tr>
<td>1598</td>
<td>Iron-clad warships are developed in Korea</td>
</tr>
<tr>
<td>1619</td>
<td>William Harvey (England) discovers circulation of blood in the body</td>
</tr>
<tr>
<td>1624</td>
<td>Johannes Baptista van Helmont (Belgium) refers to compressible fluids as “gas”</td>
</tr>
<tr>
<td>1643</td>
<td>Evangelista Torricelli (Italy) develops the barometer to measure air pressure</td>
</tr>
<tr>
<td>1652</td>
<td>Otto von Guericke (Germany) develops the air pump</td>
</tr>
<tr>
<td>1661</td>
<td>Christian Huyghens (Holland) develops the manometer to measure gas pressure</td>
</tr>
<tr>
<td>1670</td>
<td>Giovanni Borelli (Italy) develops artificial wings and attempts to fly</td>
</tr>
<tr>
<td>1672</td>
<td>Jan van der Heyde develops flexible hoses for fire fighting</td>
</tr>
<tr>
<td>1690</td>
<td>Denis Papin (France) designs a piston pump powered by steam</td>
</tr>
<tr>
<td>1707</td>
<td>Denis Papin (France) designs a high-pressure boiler</td>
</tr>
<tr>
<td>1714</td>
<td>Daniel Gabriel Fahrenheit develops the mercury thermometer with the Fahrenheit temperature scale</td>
</tr>
<tr>
<td>1742</td>
<td>Anders Celsius (Switzerland) designs a thermometer with the Centigrade temperature scale</td>
</tr>
<tr>
<td>1764</td>
<td>James Watt develops the steam condenser</td>
</tr>
<tr>
<td>1766</td>
<td>Henry Cavendish discerns density differences between hydrogen and air</td>
</tr>
<tr>
<td>1775</td>
<td>Pierre-Simon Girard develops a water turbine</td>
</tr>
<tr>
<td></td>
<td>James Watt develops the steam engine</td>
</tr>
<tr>
<td>1778</td>
<td>John Smeaton develops improved diving bells</td>
</tr>
<tr>
<td>1782</td>
<td>Montgolfier brothers develop the hot air balloon</td>
</tr>
<tr>
<td></td>
<td>James Watt develops the double-acting rotary steam engine</td>
</tr>
<tr>
<td>1787</td>
<td>John Fitch (US) develops a steamboat, and sails on the Delaware River</td>
</tr>
<tr>
<td>1795</td>
<td>Joseph Bramah develops the hydraulic press</td>
</tr>
<tr>
<td>1800</td>
<td>Richard Trevithick develops a light-pressure steam engine</td>
</tr>
<tr>
<td>1801</td>
<td>Robert Fulton (US) develops the first submarine</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
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<tr>
<td>------</td>
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</tr>
<tr>
<td>1803</td>
<td>Robert Fulton (US) develops a steam-powered boat</td>
</tr>
<tr>
<td>1805</td>
<td>Rockets are first used as military weapons in British army</td>
</tr>
<tr>
<td>1811</td>
<td>Ludwig Berblinger (Germany) attempts to fly using artificial wings</td>
</tr>
<tr>
<td>1812</td>
<td>Henry Bell develops a steam-powered ship</td>
</tr>
<tr>
<td>1815</td>
<td>US develops first steam-powered warship – U.S.S. Fulton</td>
</tr>
<tr>
<td>1827</td>
<td>Josef Ressel (Austria) develops a screw propeller for ships Sand filters used in London’s water supply system</td>
</tr>
<tr>
<td>1829</td>
<td>Josef Ressel (Austria) develops steamship with screw propeller that can reach speeds of six knots</td>
</tr>
<tr>
<td>1830</td>
<td>Steam-powered street cars are in use throughout London</td>
</tr>
<tr>
<td>1845</td>
<td>William McNaught (England) develops a compound steam engine</td>
</tr>
<tr>
<td>1859</td>
<td>Construction of Suez Canal, to connect Mediterranean Sea to Red Sea, begins</td>
</tr>
<tr>
<td>1860</td>
<td>Etienne Lenoir develops an internal combustion engine</td>
</tr>
<tr>
<td>1865</td>
<td>First oil pipeline constructed in US in Pennsylvania</td>
</tr>
<tr>
<td>1871</td>
<td>Simon Ingersoll (US) develops a pneumatic drill for rock drilling</td>
</tr>
<tr>
<td>1872</td>
<td>George Westinghouse (US) develops air brakes for rail cars</td>
</tr>
<tr>
<td>1875</td>
<td>London’s sewer system is constructed</td>
</tr>
<tr>
<td>1884</td>
<td>Charles Parsons develops the first steam turbine engine</td>
</tr>
<tr>
<td>1885</td>
<td>Karl Benz (Germany) develops a single-cylinder engine for automobiles</td>
</tr>
<tr>
<td>1888</td>
<td>John Dunlop (US) develops the pneumatic (air-filled) tire for automobiles</td>
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<tr>
<td>1892</td>
<td>Rudolf Diesel develops an internal combustion engine</td>
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<tr>
<td>1893</td>
<td>Henry Ford (US) manufactures his first car Karl Benz (Germany) manufactures his first car</td>
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<tr>
<td>1895</td>
<td>Konstantin Isiolkovski develops the theory of rocket propulsion</td>
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<tr>
<td>1898</td>
<td>Ferdinand von Zeppelin develops first airship</td>
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<tr>
<td>1903</td>
<td>Orville and Wilbur Wright (US) conduct first successful airplane flight Henry Ford establishes Ford Motor Company</td>
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<tr>
<td>1908</td>
<td>General Motors Company established</td>
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<tr>
<td>1909</td>
<td>Henri Farman (England) completes first 100-mile airplane flight</td>
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<tr>
<td>1912</td>
<td>Royal Air Force established in England S.S. Titanic sinks 1st successful parachute jump</td>
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<tr>
<td>1913</td>
<td>Rene Lorin develops theory of jet propulsion</td>
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<tr>
<td>1914</td>
<td>Robert Goddard (US) experiments with, and successfully develops, rockets</td>
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<tr>
<td>1915</td>
<td>Hugo Junkers develops first airplane for air combat</td>
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<tr>
<td>1919</td>
<td>Jakob Bjerknes develops theory of cyclones as waves between air masses J. Alcock and A. Brown conduct first nonstop transatlantic flight in an airplane</td>
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<tr>
<td>1920</td>
<td>Anton Flettner (Germany) develops metal-sailed rotor ships</td>
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<tr>
<td>1926</td>
<td>Robert Goddard tests first rocket powered by liquid fuel</td>
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<tr>
<td>1927</td>
<td>Charles Lindbergh flies “Spirit of St. Louis” from New York to Paris World’s deepest well is drilled in California, it is 8000 feet deep</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
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<tr>
<td>1928</td>
<td>Amelia Earhart conducts first flight by a woman over the Atlantic</td>
</tr>
<tr>
<td>1931</td>
<td>Percy Bridgeman (US) experiments with high pressures</td>
</tr>
</tbody>
</table>
| 1936 | Hoover Dam in Nevada / Arizona is completed  
Hindenburg airship completes first transatlantic flight |
| 1937 | Bonneville Dam in Oregon is completed  
Frank Whittle develops first jet engine  
Hindenburg airship explosion |
| 1938 | Bartlett Dam in Arizona is completed |
| 1940 | Vought-Sikorsky Corporation conducts first helicopter flight  
Tacoma Narrows suspension bridge in Washington collapses |
| 1942 | Max Muller develops the turbo prop aircraft engine  
Bell Aircraft develops first US jet airplane |
| 1943 | 1300-mile oil pipeline from Texas to Pennsylvania is constructed |
| 1946 | Rocket missiles are developed in the US |
| 1947 | First supersonic airplane flight |
| 1948 | US missiles can achieve 3000 miles per hour speed and 78 mile altitude |
| 1949 | US missiles can achieve 250 mile altitude |
| 1953 | US airplane achieves speeds of 1600 miles per hour |
| 1957 | USSR launches Sputnik I and Sputnik II artificial satellites |
| 1958 | US launches Explorer I artificial satellite  
USSR launches Sputnik III artificial satellite  
US establishes National Aeronautics and Space Administration (NASA) |
| 1959 | USSR launches a rocket with two monkeys as passengers  
USSR launches Lunik to moon  
USSR launches Lunik III to photograph moon |
| 1960 | US airplane achieves speed of 2200 miles per hour |
| 1961 | Yuri Gagarin (USSR) orbits earth  
Alan Shepard (US) achieves first US space flight |
| 1963 | Michael DeBakey is first surgeon to use an artificial heart to pump a patient’s blood during heart surgery |
| 1964 | US launches Ranger VII to photograph moon |
| 1966 | Michael DeBakey is first surgeon to use plastic artificial artery implants  
USSR launches Luna 9 to the moon  
US launches Surveyor I to the moon |
| 1968 | Aswan Dam in Egypt is completed |
| 1969 | England and France develop the commercial supersonic Concorde airplane  
First humans land on moon during Apollo 11 mission (US) |
| 1974 | US SR-71 airplane flies at 2000 miles per hour during 55-minute transatlantic flight |
| 1977 | First US space shuttle “Enterprise” completes test flight |
| 1986 | Dick Rutan and Jeanna Yeager complete first nonstop flight around the world in airplane “Voyager” |
RESOURCES FOR INSTRUCTORS

For instructors who are interested in augmenting existing fluid mechanics coursework with appropriate historical perspectives, supporting teaching materials are absolutely essential to success. Therefore, in addition to the timelines presented in this paper, an extensive listing of both recent books as well as current websites is provided below. These contain much historic information that instructors should find useful. Although only a few books have been found that specifically discuss the history of fluid mechanics and the applications of this discipline (a large number of books dedicated to the history of the airplane are currently available, but only a small fraction are actually listed here), many websites are currently available. To facilitate their use, the websites have been categorized under several broad themes, including general history of fluid mechanics, history of mathematics and science, historical figures, history of aviation and aeronautics, and history of computational fluid dynamics.

Books


Websites

General History of Fluid Mechanics

Highlights in the History of Hydraulics – Hunter Rouse, The University of Iowa
http://www.lib.uiowa.edu/spec-coll/Bai/hydraul.htm
Historical Graphics and The History of Hydraulics Book Collection – Hunter Rouse, The University of Iowa
http://www.iihr.uiowa.edu/products/history/hoh/index.html
http://lvov.weizmann.ac.il/physword/physword.html
Sketching the History of Statistical Mechanics and Thermodynamics – Jeff Biggus, HyperJeff Network

Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition
Copyright © 2005, American Society for Engineering Education
http://history.hyperjeff.net/statmech.html

History of Mathematics and Science

Mathematicians of the Seventeenth and Eighteenth Centuries – David R. Wilkins, School of Mathematics, Trinity College, Dublin, Ireland  
http://www.maths.tcd.ie/pub/HistMath/People/RBallHist.html
http://www.mhs.ox.ac.uk/
The MacTutor History of Mathematics Archive – University of St. Andrews, Scotland  
http://www-history.mcs.st-and.ac.uk/~history/
World of Scientific Biography – E. Weisstein, Wolfram Research  
http://scienceworld.wolfram.com/biography/

Historical Figures

Daniel Bernoulli and the Making of the Fluid Equation – D. Quinney, Keele University  
http://pass.maths.org.uk/issue1/bern/index.html
Dr. Theodore von Karman – Ace Flyer  
http://www.aceflyer.com/
http://www.fluidmech.net/msc/euler.htm
http://www.fluidmech.net/msc/prandtl.htm
http://www.fluidmech.net/msc/newton.htm
Henry Darcy and His Law – Glenn Brown, Biosystems and Agricultural Engineering, Oklahoma State University  
http://biosystems.okstate.edu/darcy/
Prandtl – Niall McMahon, Computer Applications, Dublin City University  
http://student.dcu.ie/~mcmahon4/bioprandtl.html

History of Aviation and Aeronautics

Canada Aviation Museum  
http://www.aviation.technomuses.ca/
Canadian Aviation Historical Society  
http://www.cahs.com/
Canadian Warplane Heritage Museum  
http://www.warplane.com/
Hiller Aviation Museum  
http://www.hiller.org/
History of Aeronautics – Florida International University  
http://www.allstar.fiu.edu/aero/#history
Kansas Cosmosphere and Space Center  
http://www.cosmo.org/
A challenge for educators is to either develop or find appropriate materials for use in their own classrooms. The aforementioned teaching resources, which include a fairly extensive listing of books and websites, offer a plethora of historic information, and should provide ample materials for instructors to use. Even though the authors have tried to be exhaustive, many more websites currently exist which are not listed here, and the reader is encouraged to explore the Internet for more.

**CONCLUSIONS**

Examining the historical background of fluid mechanics is very valuable to students, so that they understand that it is not just a static body of knowledge, theories, and equations that they have to learn in order to solve problems, so that they can pass their class and thus make progress toward earning their engineering degrees. Rather, it has a rich history that can trace its roots back to antiquity. In fact, its earliest applications were fundamental to the development of human
civilization itself. From that point onward throughout its history, applications and inventions developed through trial and error as well as mathematical theory have yielded many substantial results, including that of air transportation as well as space exploration, not to mention safe and sanitary drinking water supplies. As in the past, this discipline will continue to serve humanity, and many exciting applications are yet to be developed. Furthermore, ASEE is now actively pursuing its K-12 initiative and the history of engineering offers an excellent avenue to reach out to school children of all ages. This paper provides an insight that fluid mechanics and fluid power have been well served by a great number of scientists and engineers whose work could inspire an entirely new generation of engineers.

REFERENCES


BIOGRAPHICAL INFORMATION

KURT A ROENTRATER is a Lead Scientist with the United States Department of Agriculture, Agriculture Research Service, in Brookings, SD, where he is spearheading a new initiative to develop value-added uses for residue streams resulting from biofuel manufacturing operations. He is formerly an assistant professor at Northern Illinois University, DeKalb, IL, in the Department of Technology.

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