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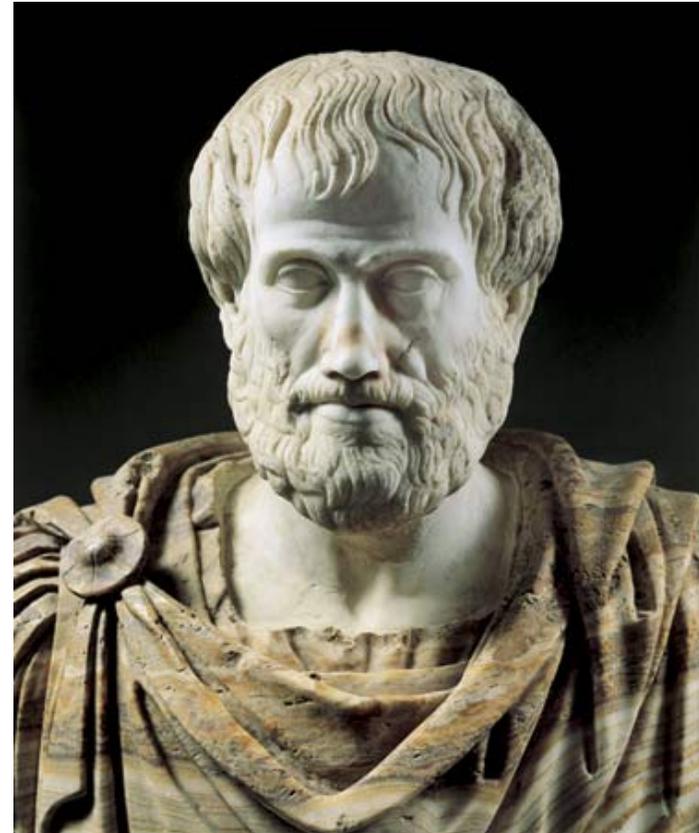
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Historical Background to Modern Science & Engineering

Philosophy, derived from the Greek meaning 'love of wisdom' was used interchangeably with science until the 17th Century - known as '**natural philosophy**' since ancient Greek times.

After that science and the humanities came to be recognised as separate and distinct branches of knowledge, and the former became known as '**natural science**'.

Aristotle (384-322 BC) 'father of science'



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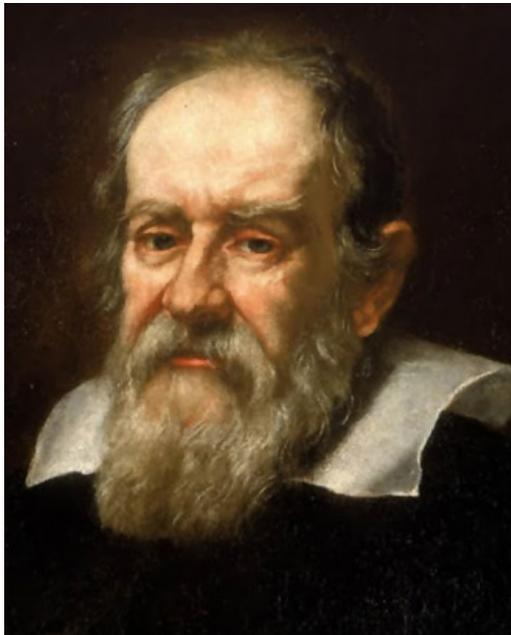
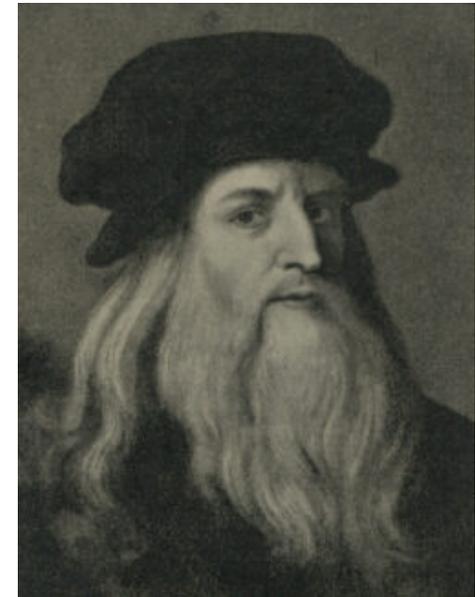
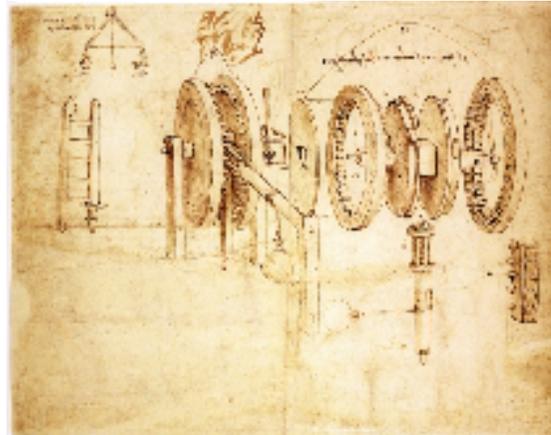
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Renaissance

..great flourishing of the arts, philosophy, science and engineering.



Leonardo da Vinci (1492-1519)
and his drawings of toothed
gears



Galileo (1564-1642) suggested that he could
conceive **natural, mechanical explanations** for all
natural phenomena except perhaps for the tides.

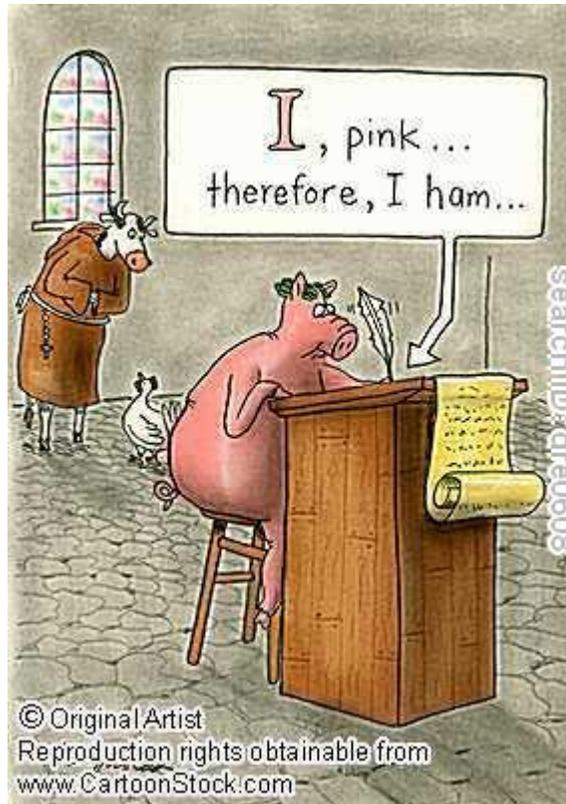
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Early Modern times

René Descartes (1596-1650)





Early Modern times

René Descartes (1596-1650) introduced the **Cartesian coordinate system**.

He pioneered '**rationalism**': i.e. **reason alone** was the way to '**truth**' and **reality**. Input from the **senses** and **intuition** are unimportant here.

*"Deal only with ideas that are **distinct, precise, beyond any reasonable doubt**; therefore rely on **geometry, mathematics, quantification, measurement and exact observations**."*



Descartes also proposed the idea of '**dualism**'; humans consist of two components; a mechanical body and a mind or soul ('res cogitans') which allows for free will.

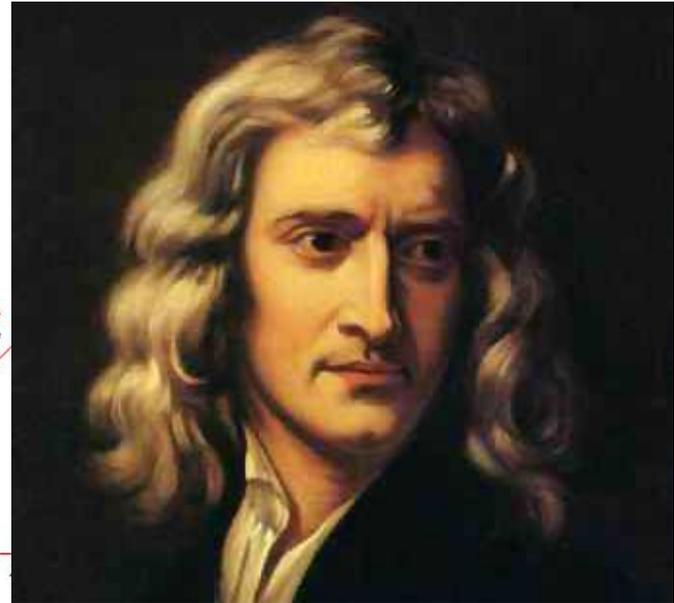
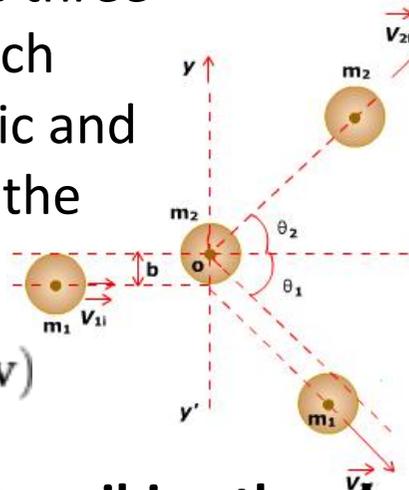


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Early Modern times

Issac Newton (1642-1726) developed infinitesimal calculus and the three universal laws of motion which enabled many of the scientific and technological advances over the following centuries.

$$\mathbf{F} = \frac{d}{dt}(m\mathbf{v})$$



$$m_1\mathbf{v}_1 + m_2\mathbf{v}_2 = m_1\mathbf{v}_1 + m_2\mathbf{v}_2$$

The success of scientists in **describing the physical world** by reducing it to **mathematical formulae** which approximated reality helped shape the increasingly commonly held view that all of nature could eventually be described scientifically and that there are **no inherently unknowable facts**.

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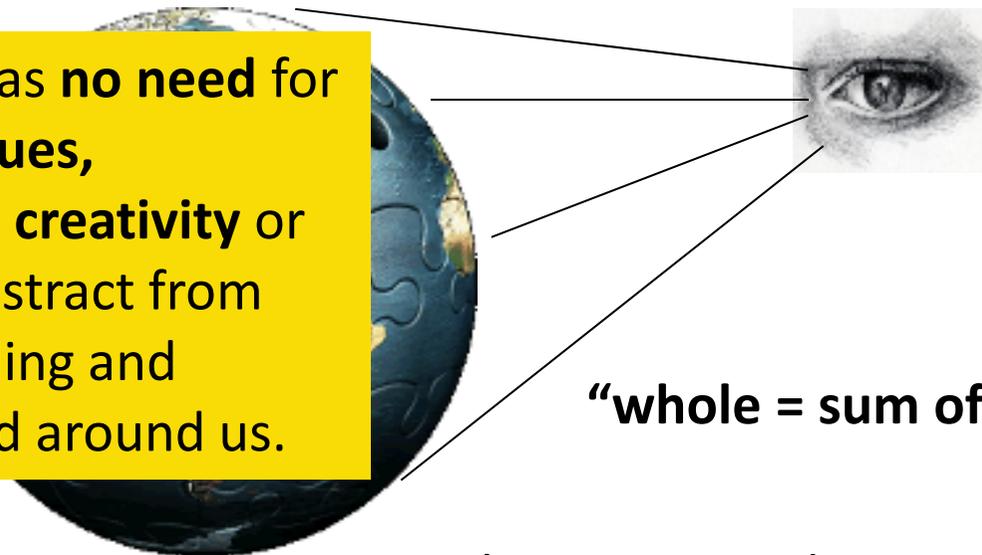
Age of Enlightenment (18th C)

(*'Age of Reason'*)

Replace religious faith, dogma & superstition by humanist, rational, detached, **object world** view.

'Universal truth' can be found through the **scientific method**.

Reductionist science has **no need** for intangibles such as **values, emotions, inspiration, creativity** or **intuition**. These just distract from the task of understanding and manipulating the world around us.



"whole = sum of parts"

Reductionist, positivist or **atomistic** approach: We can understand the world around us by breaking it down into ever smaller discrete parts, each of which when thoroughly understood and described can then be fitted together to describe (and predict) how the whole operates.

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Reductionist approach..



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“whole = sum of parts”

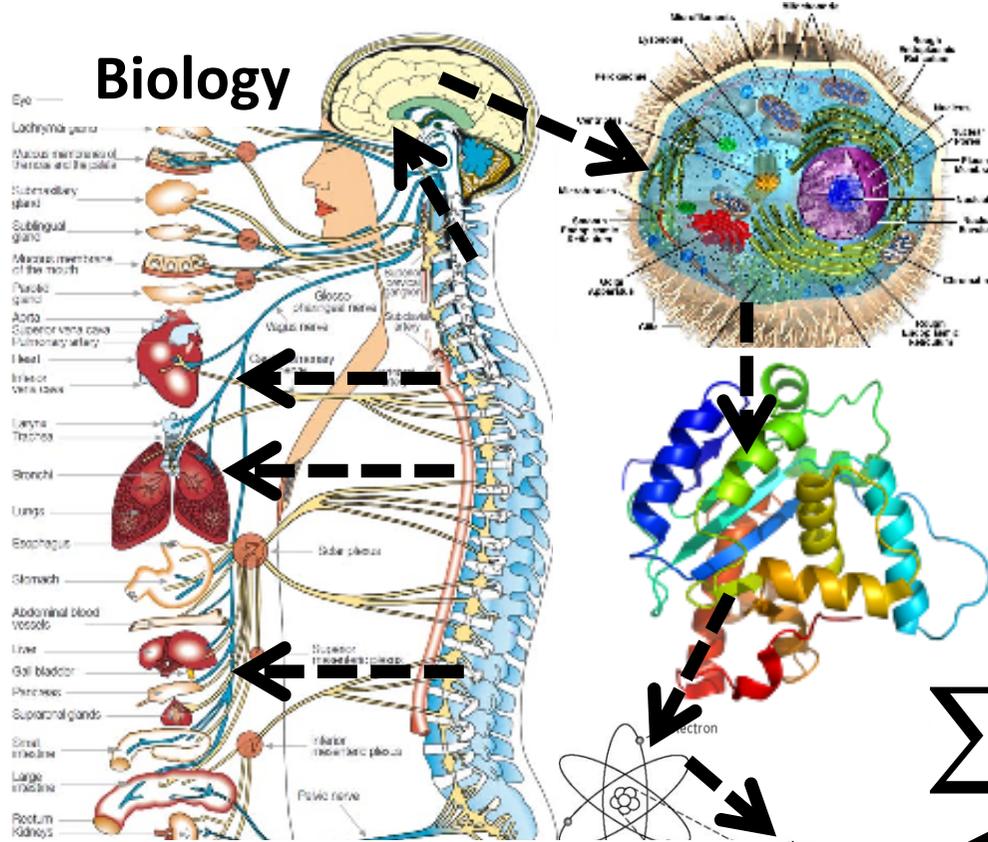
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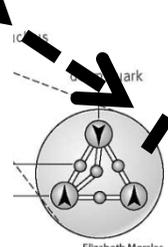
Reductionist approach..

love, happiness, inspiration??*



~~Love, happiness, inspiration???~~

$\Sigma \Sigma \Sigma$



Physics

*An irrelevant distraction from understanding and manipulating the world around us (mind vs. body)



Reductionist Approach

‘Silo effect’ of learning: Each discipline has its own expert conception of the world, their own

‘object world’



Social sciences

- Anthropology
- Archaeology
- Area studies
- Cultural and ethnic studies
- Economics
- Gender and sexuality studies
- Geography
- Political science
- Psychology
- Sociology

Humanities

- History
- Languages and linguistics
- Literature
- Performing arts
- Philosophy
- Religion
- Visual arts

Natural sciences

- Space sciences
- Earth sciences
- Life sciences
- Chemistry
- Physics

Formal sciences

- Computer sciences
- Logic
- Mathematics
- Statistics
- Systems science

Professions and Applied Sciences

- Agriculture
- Architecture and design
- Business
- Divinity
- Education
- Engineering
- Environmental studies and Forestry
- Family and consumer science
- Health sciences
- Human physical performance and recreation
- Journalism, mass media and communication
- Law
- Library and museum studies
- Military sciences
- Public affairs
- Social work
- Transportation



19thC Determinism

Pierre-Simon de Laplace (1749-1827) believed in a reductionist philosophy that conceived the universe as a giant machine which obeys the ‘billiard ball hypothesis’, i.e. once the initial conditions of the universe have been established, the rest of its history follows inevitably, as one unique set of circumstances follows another - and hence all is predetermined (**‘causal determinism’**)



‘Laplace’s Demon’ (1812):

*..an intelligence with infinite calculable ability would be able to predict all future events if all past and present entities and forces in the universe were known at a given instant. Thus **‘nothing would be uncertain and the future, as the past, would be present to its eyes.’***

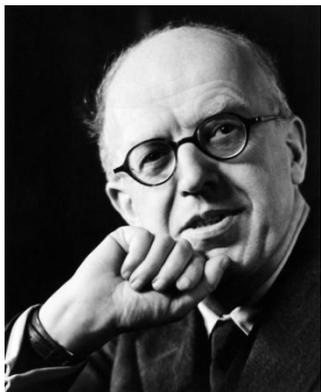
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Modernity and the Two Cultures

The world of Galileo, Descartes, Newton and Laplace is essentially **mechanistic**, **deterministic** and **reductionist**

It can be described by equations which only need to be **uncovered** either through reason or experimentation or both, so that once the correct coefficients are determined future states can be predicted.



Since the **mid 1600's**, **rational science** and **relational humanities** have carried different concepts of reality, each often distrustful of the other. The centuries since have been characterised as the **'modern' era**. In 1965 Cambridge physicist **C.P. Snow** famously identified (and bemoaned) this break in **'The two cultures'**.

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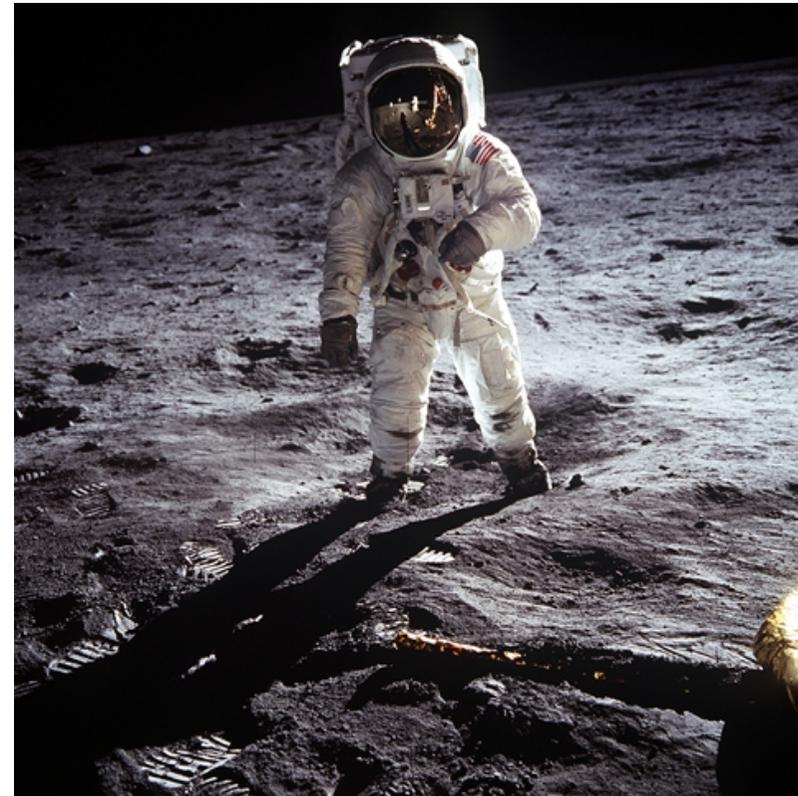


Historical context; Modernity

Newtonian physics has proved **hugely successful** and provided a basis for the formation of the modern world; from the onset of the industrial revolution and further scientific advances through the 19th and 20th right through sending **mankind** to the **moon** in **1969** and beyond.

This influence was so great, that most people with a basic notion of science still implicitly equate “scientific thinking” with “Newtonian thinking”.

(Heylighen et al, 2007)





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20th Century Developments

Cartesian/Newtonian science shown to be only a partial representation of scientific reality in the 20th Century..

- **Einstein's** Theory of Relativity (1916)
- **Heisenberg's** Uncertainty Principle (1927)
- **Gödel's** Incompleteness Theorem (1931)*
- **Poincaré's** work (1908) & Lorenz's Chaos Theory (1963), followed by Complexity Theory

**uncertainty is always present, and thus some things cannot be proved logically and rationally*



Albert Einstein & Kurt Gödel

Einstein also valued experiential knowledge as well as theoretical/scientific:
"Pure logical thinking can give us no knowledge whatsoever of the world of experience; all knowledge about reality begins with experience and terminates in it."

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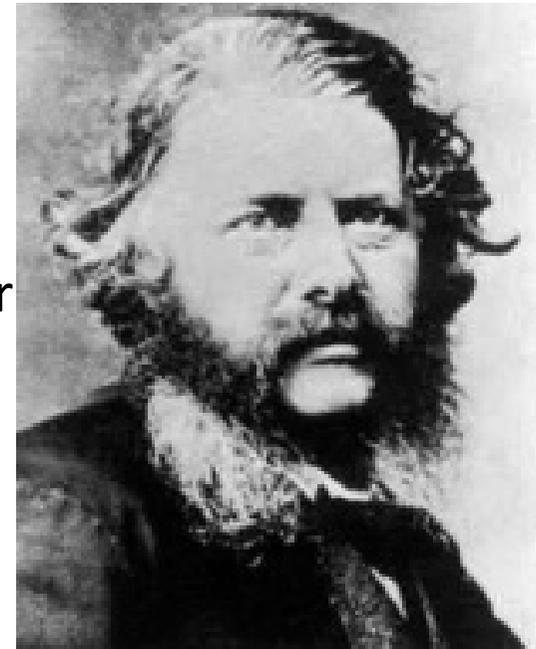


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History of Engineering Education

19th Century: Professional engineering programmes were established in universities with scientific and scholarly bases to educate gentlemen. Engineering sought academic respectability and a share in the growing prestige of science. Contrasted with the practical hands-on vocational training approach.

William J.M. Rankine; Scottish academic engineer helped develop thermodynamics and sought to develop a recognised core of Engineering fundamentals to *'transcend the traditional categories of theory and practice'*.

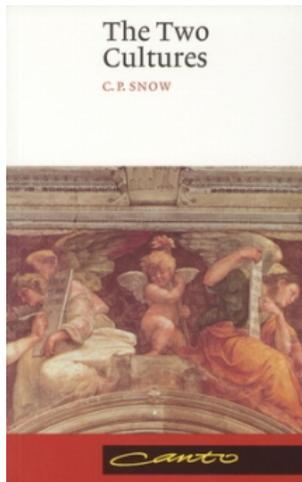


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History of Engineering Education

1950's: 'Engineering science' approach becomes more central to the curriculum as **scientific content of undergraduate programmes **increased**.**



The Two Cultures:

This has led to a suggestion that '*the **non-scientific component of technology** [e.g. judgement, experience, understanding of social complexities, creativity and visual skills] has been **neglected** in engineering education because it origins lie in **art** rather than **science**'.*

*As a result, 'in scientific courses students learn there is only **one right answer** to the problems they are set ..yet **there is seldom only one solution to real life problems**, nor one way of going about things'.*

Sharon Beder, The New Engineer (1998)

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History of Engineering Education

Beder: *'The **overemphasis on science** in engineering has not only led to a **neglect of social dimensions** by engineers but also to a **faith in technological solutions** that is often **not warranted**.'*

*'Fortunately this is changing, and the profession now recognises the need to **broaden** the range of young people choosing and selected for engineering, the type of education they receive, and the outlook, focus and concerns of future engineers.*

*Only then can the **new engineer** emerge ready for the **21st Century**.'*