$E=mc^2$ is wrong? - Sixty Symbols

http://www.youtube.com/watch?v=mkiCPMjpysc

1) Who and when formulated this famous equation?
2) What do the letters E, m, and c denote in the equation?

Listen to and watch the video and decide whether the statements are true or false.

1) Mass of particles can be measured in joules.
2) Considering the Newton's Laws of Motion, energy is the same as mass.
3) Large amount of energy is equivalent to huge amount of mass.
4) Mass is always a source of energy.
5) p2 c2 indicates movement.
6) In the original equation, mass is moving.
7) M0 means that there is no momentum of a particle.
8) Speed of sound is not used because it is a much higher number.
9) People do not realize how important this equation is.
10) The public is not able to understand **$E=mc^2$** because it is too complicated.

The greatest equations ever

Critical Point: October 2004 Robert P Crease

Pre-reading

These are some equations mentioned in the text. Try to specify what these equations indicate.

1) $E = mc^2$ 3) $1 + 1 = 2$ 5) $\delta S = 0$. A 7) $a/b = c/d$

2) $F = ma$ 4) $v = H_0 d$ 6) $e^{i\pi} + 1 = 0$ 8) $a^2 + b^2 = c^2$

9) $V = IR$ 10) $PV = nRT$

Read the text and check your answers.

Maxwell's equations of electromagnetism and the Euler equation top a poll to find the greatest equations of all time. Robert P Crease discusses the results of his reader survey

Earlier this year I asked readers to send me their shortlists of great equations. I also asked them to explain why their nominations belonged on the list and why, if at all, the topic matters (*Physics World* May p19).

I received about 120 responses -- including single candidates as well as lists -- proposing about 50 different equations. They ranged from obvious classics to "overlooked" candidates, personal favourites and equations invented by the respondents themselves.

Several people inquired about the difference between formulae, theorems and equations -- and which I meant. Generally, I think of a formula as something that obeys the rules of a syntax. In this sense, $E = mc^2$ is a formula, but so is $E = mc^3$. A theorem, in contrast, is a conclusion derived from more basic principles -- Pythagoras's theorem being a good example. An equation proper is generally a formula that states observed facts and is thus empirically true. The equation that describes the Balmer series of lines in the visible spectrum is a good example, as are chemical equations that embody observations about reactions seen in a laboratory.

However, these distinctions are not really so neat. Many classic physics equations -- including $E = mc^2$ and Schrödinger's equation -- were not conclusions drawn from statements about observations. Rather, they were conclusions based on reasoning from other equations and information; they are therefore more like theorems. And theorems can be equation-like for their strong empirical content and value.

It thus makes sense to classify both kinds as equations, which is exactly what respondent David Walton from the University of Manchester did. He distinguished between equations (such as $F = ma$) that comprise axiomatic models that "define the interrelationships between various observables for all circumstances" and equations that are approximate models (such as Hooke's law), which define "the interrelationships between the various observables over a defined range and within a defined accuracy". I therefore interpreted the term "equation" loosely.

Simplicity

Respondents had many different criteria for greatness in equations. Half a dozen people were so impressed with simplicity that they proposed $1 + 1 = 2$.

"I know that other equations have done more, express greater power [and have a] broader understanding of the universe," wrote Richard Harrison from Calgary in Canada, "but there's something to be said for the beauty of the simplest things of their kind." He then recalled how $1 + 1 = 2$ was the first equation he taught his son. "I remember [him] holding up the index finger of each hand as he learned the expression, and the moment of wonder when he saw that the two fingers, separated by his whole body, could be joined in a single concept in his mind."

Other simple equations that were proposed included $v = H_0 d$, which Edwin Hubble composed in 1929 to describe the fact that the galaxies are moving away from us at a speed, v, that is proportional to their distance, d, where H_0 is the Hubble constant. Balagoj Petrusev, an undergraduate student at the Institute of Physics in Skopje, Macedonia, suggested the Hamiltonian variational principle in the form $\delta S = 0$. A proper selection of the form of **S** articulates "a universal principle that stands true in classical mechanics, classical electrodynamics, relativistic mechanics, non-relativistic quantum mechanics and so on".

One of the most frequently mentioned equations was Euler's equation, $e^{i\pi} + 1 = 0$. Respondents called it "the most profound mathematical statement ever written"; "uncanny and sublime"; "filled with cosmic beauty"; and "mind-blowing". Another asked: "What could be more mystical than an imaginary number interacting with real numbers to produce nothing?" The equation contains nine basic concepts of mathematics -- once and only once -- in a single expression. These are: e (the base of natural logarithms); the exponent operation; π; plus (or minus, depending on how you write it); multiplication; imaginary numbers; equals; one; and zero.

Practicality

Many respondents were impressed by equations that have a practical influence on human life. These included: the compound-interest equation, the implications of which from the Renaissance to the present are "obvious, staggering and unwelcome"; income-tax formulae; the simple ratio $a/b = c/d$, which is basic to construction, surveying and so forth; simple electrical equations, such as $V = IR$; basic mechanical equations, such as work done = force x distance; Shannon's capacity equation, which relates to the modern world through the Internet and digital communication; and, last but not least, Pythagoras's theorem.

Roger Bailey nominated the "sunrise equation" cos(time) = -tan(lat) x tan(dec), which identifies the time of sunrise or sunset as a function of latitude and solar declination. This, he pointed out, is "fundamental to our sense of time" and it "fits on a T-shirt". Engineer John Wilcher suggested the ideal-gas law, $PV = nRT$, pointing out that "the relation of pressure, volume and temperature is relevant to almost everything we do", including common but often overlooked uses such as car tyres, angioplasty procedures and oil drilling.

Post-reading

1)Read the first part of the text again and explain the difference between **formula, theorem, and equation.**

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2) Read the parts **Simplicity** and **Practicality** and write down why these equations are special for the people who nominated them.

a) 1+1=2 ____

b) $\delta S = 0$. A____

c) $e^{i\pi} + 1 = 0$____

d) cos(time) = -tan(lat) x tan(dec)____

e) $PV = nRT$____

Word study:

Fill in the missing prepositions:

a) They ranged ________ obvious classics ___________ „overlooked“ candidates.
b) Conclusions drawn _________statements __________observations.
c) Conclusions based ________reasoning ___________other equations.
d) People were impressed _________simplicity.
e) A practical influence ___________human life.
f) It is relevant ___________almost everything.
g) Observations ___________reactions seen in a laboratory.

Conclusion:

This is the result of the survey, i.e. the 20 greatest equations. Work with your neighbour and choose three most important or interesting equations. Justify your choice.

A) Dr. Robert P. Crease once asked readers of Physics World magazine, which equation was the greatest for them. He received more than one hundred replies and fifty different opinions. People nominated very complicated equations, that describe much more complicated phenomena, but also equations simple and well-known. It isn´t easy to choose from them the greatest one, because everybody finds something different as the most important.

B) Which equations are the greatest? Answer to this question isn´t simple. A great equation "reshapes perception of the universe." Many prominent scientists have their own favorite equations such as, for example Euler´s equation, Schrodinger equation or the Pythagorean theorem. But for many people the greatest equation is "1+1=2"- the fairy tale of mathematics.

C) Equations describe a lot of processes of the universe and it isn´t easy to choose the greatest one. And this was the question for readers of Physics Word magazine. Prominent scientist Mr. Harrison chose 1+1=2, which is easy to understand and dr. Brian Greene prefered Einstein´s general relativity equations and Schrödinger equations, and another 50 different equations were choosen.

D) Physics Word magazine asked a question: Which equations are the greatest. 120 responses nominated 50 different equations, which were well known for their simplicity or historical importance. Prominent scientists had their own favourites, for example Pythagorean theorem, Maxwell´s equation and Eistein´s general relativity equations.

E) The article sorts the problem of equations. Which one is the greatest one and why.

F) A survey among readers of Physics World magazine tried to find the greatest equations. Although no equation became a "winner", the readers usually voted for simple equations with only a few symbols but very important for further development of mathematics or physics.