Albert Einstein

36 pt Times New Roman centered

The Special Theory of Relativity

16 pt.

12 pt.

Doug Harper
UC 101-041: Assignment 4

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Between 1900 and 1927 there were two great revolutions in physics: quantum mechanics and relativity. The former grew from contributions by many physicists (including Einstein), but relativity was the creation of Einstein alone, a stunning accomplishment ranking easily with the achievements of Newton. Einstein based his theory on two assumptions:

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1. All the laws of physics have the same form in all inertial reference frames. This is often called the **Principle of Relativity**.

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2. The speed of light in a vacuum has the same value c in all inertial reference frames. This is called the **Principle of the Constancy of the Speed of Light**.

The entire theory of special relativity is derived from just these two postulates. Their simplicity and generality are characteristic of Einstein's genius. As a consequence, Einstein showed that Newtonian Mechanics is only approximately correct, usable in cases in which velocities are small compared with the speed of light. In fact, Einstein's relativistic mechanics approaches Newtonian mechanics when $v << c$. As Richard Feynman[1] stated in his now famous *Lectures on Physics*

footnote

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> For over 200 years the equations of motion enunciated by Newton were believed to describe nature correctly, and the first time that error in these laws was discovered, the way to correct it was also discovered. Both the error and its connection were discovered by Einstein in 1905. Newton's Second Law, which we have expressed by the equation
>
> Use Equation editor → $$\vec{F} = \frac{d}{dt}(m\vec{v}) \quad (1)$$ Hint: Use TABS
>
> was stated with the tacit assumption that m is a constant, but we now know that is not true, and that the mass of a body increases with velocity. In Einstein's corrected formula m has the value
>
> $$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (2)$$
>
> where the "rest mass" m_0 represents the mass of a body that is not moving and c is the speed of light, which is about 3×10^5 km sec^{-1} or about 186,000 mi sec^{-1}.

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> For those who want to learn just enough about it so they can solve problems, that is all there is to the theory of relativity- it just changes Newton's laws by introducing a correction factor to the mass. From the formula itself it is easy to see that this mass increase is very small in ordinary circumstances. If the velocity is even as great as that of a satellite, which goes around the earth at 5 mi/sec, then v/c=5/186,000: putting this value into the formula shows that the correction to the mass is only one part in two to three billion, which is nearly impossible to observe. Actually, the correctness of the formula has been amply confirmed by the observation of many kinds of particles, moving at speeds ranging up to practically the speed of light. However , because the effect is ordinarily so small, it seems remarkable that it was discovered theoretically before it was discovered experimentally. Empirically, at a sufficiently high velocity, the effect is very large, but it was not discovered that way.

The interested reader can find additional information about Einstein's Theory of Relativity from Einstein himself in a book for the layperson entitled *Relativity: The Special and General Theory*[2]. Some additional accomplishments of Albert Einstein are summarized in the table below.

Table 1
Some Important Dates in the Life of Albert Einstein

This is created using the Table feature.

YEAR	Activity
1905	Published four papers on the photoelectric effect, Brownian motion, and the special theory of relativity.
1916	Published the General Theory of Relativity.
1921	Received the Nobel Prize for his explanation of the photoelectric effect.
1939	Lent his name to a letter to President Roosevelt urging immediate investigation into the possibility of a nuclear bomb.

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[1] Feynman, Richard P., *Six Not-So-Easy Pieces: Einstein's Relativity, Symmetry and Space-Time* (Addison-Wesley, Massachusetts,1997).

[2] Einstein, Albert, *Relativity: The Special and General Theory - A clear explanation that anyone can understand* (Crown, New York, 1916).

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