Something to Think About

As the distance \( r \) from the Earth’s center increases, how does the acceleration of gravity \( g \) above the Earth surface vary with \( r \)?

Note from the Editor

This, 100th newsletter, maybe the last Science Teachers’ Newsletter. For information on future newsletters, check the Physics and Astronomy webpage in September 2014, let us know if you wish us to continue them. The web address is phy.ohiou.edu/stnl.

Announcements

- The 2014 Southeast Ohio District Science Day will be held on Saturday, March 15, 2014. It will be held at Ohio University in Athens, Ohio. Judges are needed. Would you volunteer? Let Dr. Elizabeth Gierlowski-Kordesch know if you can help. Her email is gierlows@ohio.edu. The web address is www.ohio.edu/scifair/.

- The 2014 State Science Fair will be held at Ohio State University in Columbus, Ohio, on Saturday, May 10, 2014.

- The International Science and Engineering Fair will be held in May, 2014.

- The AMERICAN ASSOCIATION OF PHYSICS TEACHERS APPALACHIAN SECTION (Southeast Ohio, West Virginia and Western Maryland), will hold a FALL 2014 MEETING at Frostburg State University in Frostburg, Maryland. All school and college physical science and physics teachers are welcome. Why don’t you consider joining this AAPT Section or the Ohio Section or the Southern Ohio Section? There are contributed and invited papers, tours, demonstrations, etc. that are included in
the meeting. The meetings are an opportunity to meet colleagues (network) and to learn about new developments in physics and physics teaching.

**Teaching Materials Available**

**Books and Publications**

✧ Here is a book that would be useful for some students taking introductory physics. It is *The Theoretical Minimum*- What you Need to Know to Start Doing Physics. L. Susskind and G. Hrabovsky are the authors and the publisher is Basic Books, New York, 2013, there are 238 pages; See the review in *Physics Today*, June 2013, on page 54, 55 the price is $26.99.

✧ *Nuclear Forces*- The making of the Physicist Hans Bethe by S.S. Schweber. It is a good, interesting biography of Hans Bethe. It was published by Harvard Press in 2012. The book has 579 pages and costs $35.00. See the reviews, in *Physics Today* for April, 2013 on page 50, 51.

✧ *Why You Hear What You Hear*- An Experimental Approach to Sound, Music and Psychoacoustics. The author is Eric J. Heller and the publisher is Princeton U. Press, Princeton, N.J. It has 624 pages and costs $99.50. The book has a website where can be found: help on software use and wave animations. There is a substantial review on pages 51 and 52 in *Physics Today*, April 2013.

✧ *Train Wreck:* the Forensics of Rail Disasters by George Bibel. The publisher is Johns Hopkins University Press and the price is $29.95 for the paperback. It was published in 2012 and describes why wrecks occur due to human failure and/or equipment failure. For more information, see *The Physics Teacher*, May, 2013 on page 319.

✧ *Are We Being Watched? Are we alone in the Universe?* This book was published by Thames and Hudson in 2013 and costs $24.95 *Science News* June 1, 2013 has more information on page 30.
Demonstrations, Software, Equipment, Tours, Careers, etc.

✧ AAPT publishes a brochure that should be most helpful for physics teachers in high school. The title is *The Role, Education, Qualifications and Professional Development of Secondary School Physics Teachers*. It was written in 2009 and can be found using www.aapt.org.

✧ AAPT has a Career Center. It posts jobs and resumes for physics teachers at high schools, two-year and four-year colleges and universities worldwide. Use careers@aapt.org or telephone at 301-209-3191

✧ Words Science has over 700 items for teaching introductory and advanced physics courses. The items include-inquiry-based kits, engineering kits, apparatus, supplies, and equipment. Use wardsci.com

✧ PASCO offers Capstone software for use in collecting data and analysis for the physics laboratory. Version 1.1 is compatible with MAC and Windows. It has powerful video analysis, histograms and is free to those who use Capstone.

✧ Collect and process sensor data with Vernier’s Lab Quest 2 on these devices- Ipad, Android Tablet, and other mobile devices with web browsers. For information use www.vernier.com/css.

✧ 3B Scientific has electron tubes that can be used to show nuclear experiments and quantum physics in classroom demonstrations. Use 3Bscientific.com

✧ There is an interesting LEGO anharmonic rocker demonstration described in Physics Teacher, April 2013 on page 231. The rocker’s period of oscillation is shown to depend on the amplitude. As the amplitude of the rocker, made from Lego bricks, decreases the frequency increases.
Tours for Middle and High School Students are given by the Department of Physics and Astronomy at Ohio University in Athens. Contact Wayne Chiasson at Chiasson@ohio.edu or 740-593-1712. We have experimental research facilities in surface physics, nuclear physics, optical physics and astrophysics.

New Developments in Science and Science Education

Jefferson Lab in Newport News, Virginia publishes readable, handy brochures for teachers that discuss its research equipment and projects. The Lab is, in the future, increasing its continuous electron beam energy from 6 Bev to 12 Bev. The electrons are used to probe atoms and their protons, neutrons, quarks and gluons. Among the areas to be studied are:

1. Quark confinement- quarks bound in a pair by a strong binding force. These exist as single quarks.
2. Fundamental structure of protons and neutrons
3. How protons and neutrons react to form nuclei
4. Tests of the Standard model. This model describes fundamental particles and their interactions.

Use email for information- education @ jlab.org or phone (757)-269-7567.

Note Bev- $10^9$ electron volts. 1 electron volt (ev) is the energy increase gained by an electron accelerated through a potential difference of 1 volt.

There are several articles on the discovery of the Higgs Boson which is important for the Standard Model. The Higgs Boson helps explain particle mass. Two of these articles are found in: Science News, December 29, 2012 on pages 16, 17 and the Physics Today, June 2013, on pages 38 to 44. In the second article, the Large Hadron Collider is described and photos of it are shown.
Water in the atmosphere is the title of an article in the Physics Today issue of June 2013 on pages 29 to 34. It points out that climate changes are caused by the interactions between water, air circulation, and temperature. There are descriptions and data from experiments presented.

Some issues or matters, which are current in science are:
Crowd-funding by scientists
Dual-Country Careers
China’s intent to spend billions on science and technology
Carbon captures
Note these issues and others are discussed each month in Physics Today.

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According to supersymmetry, particles in the ordinary world each have a heavy partner. This theory predicts that the mass of the Higgs particle (a boson that is associated with mass) is finite. To further understand the Higgs Boson requires that the Large Hadron Collider go to high energies. See Science News, December 29, 2012 on pages 16 and 17.

Feature Article

Refraction of Sound in the Ocean

This article was written by Dr. F.B.Stumpf, an emeritus professor of physics at Ohio University in Athens. He is a member of the Acoustical Society of America and the Appalachian Section of the AAPT. He graduated from North Canton H.S. in North Canton, Ohio. His B.S. is from Kent State, M.S. from Michigan, and Ph.D. from the Illinois Institute of Technology. Dr. Stumpf taught undergraduate and graduate courses in physics. He also wrote the text Analytical Acoustics, published by Ann Arbor Science.
The velocity of sound in seawater depends on temperature, depth or pressure, and salinity. The temperature and depth dependence is, in approximation to Wilson’s equations,

\[ c = (1.449 + 4.6 t + 0.017 h) \text{ m/sec}^1, \]

where \( t \) is in degrees centigrade and \( h \) is in meters. A plot of the ray for several cases of temperature gradient is given in Figures 1 and 2. Introductory physics textbooks discuss the reflection and refraction (bending) of light rays at boundaries. The same laws (reflection and Snell’s) hold for sound waves. The rule is that the ray bends away from the normal to the boundary if the velocity increases in the second medium and bends toward the normal if the velocity decreases in the second medium.

It is shown \(^2\) that for a constant velocity gradient the ray is a circular arc with a radius, \( R \), given by \( R = C_0 / G \), where \( C_0 \) is the velocity at the source and \( G \) is the velocity gradient. The direction of bending depends on the sign of \( G \). Further, if a ray starts out horizontal, or nearly so, to the surface of water in which there is a constant negative gradient \( G \), an approximate form (for \( h < x \)) for the range \( x \) at which the ray is at depth \( h \) is

\[ x = \sqrt{\frac{2C_0 h}{G}} \]

as shown in Seto\(^2,3\). The exact form is shown in Seto to be

\[ x^2 = \frac{2C_0 h}{G} - h^2 \]
For a negative temperature gradient the bending is shown in Figure 1.

Figure 1. Ray bending due to a negative temperature gradient. Medium 1 is warm water and medium 2 is cold water.

For a positive temperature gradient the bending is shown in Figure 2.

Figure 2. Ray bending due to positive temperature gradient. Medium 1 is cold water and medium 2 is warm water.

Answer to Something to Think About

The expression for $g$, (the acceleration of gravity) can be written using the force on a mass($m$) above the Earth’s surface. At radius ($r$) greater than the earth’s radius, $R$, the force on $m$ is

$$
mg = \frac{GmM}{r^2}
$$

Here $M$ is the mass of the Earth. The force $m$ here can be shown, by an integral, that above the Earth’s surface the gravitational force on the mass ($m$) can be considered as that between two point masses. One point mass is $m$ and one is for the Earth’s total mass concentrated at its center. Thus the acceleration $g$ can be written

$$
g = \frac{GM}{r^2}
$$

This shows that above the Earth’s surface $g$ varies as $1/r^2$. Note $G$ is a constant and the gravitational constant is $6.6742\times10^{-11}$ Nm$^2$Kg$^{-2}$. Put the units in the equation for $g$ and see if the right side gives m/sec$^2$ for acceleration. Plot a graph (without numbers) for $g$ versus $r$. 