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Weather and Climate

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Weather and Climate and the MSTEF

"The nature of science" (from the Framework's description of the "Purpose and Nature of Science and Technology/Engineering on page 3)

Science may be described as attempts to give accounts of the patterns in nature. The result of scientific investigation is an understanding of natural processes."

One of the bulleted examples of a pattern seen in nature is:

- **Weather in North America generally moves from west to east.**

What do you do if they want proof that this is true?

What do you do if the ask why this is true?

Project 2061's description of the nature of science.

http://www.project2061.org/tools/sfaaol/chap1.htm

The Great Balancing Act

What Are We Asked To Teach?

and

What Do We Love To Teach?

What is your favorite source of weather information?

www.weather.com

http://www.noaa.gov/

What ARE We Asked To Teach?

Before 2001 it was:

- Inquiry
- Domains of Science
- Technology and Science
- Technology and Human Affairs

After 2001 it became:

- Earth and Space Science
- Life Sciences
- Physical Sciences
- Technology/Engineering

Guiding Principle II (page 7)

"An effective science and technology/engineering program builds students' understanding of the fundamental concepts of each domain of science and their understanding of the connections across these domains and to basic concepts in technology/engineering."

How do we follow this principle?

The Framework Online

http://www.doe.mass.edu/

What's New With The MCAS?

- Pilot Technology/Engineering MCAS for Grade 9/10
- Pilot Physics MCAS for Grades 9/10

Is there a trend developing here?

http://www.doe.mass.edu/

Educators Services -> teaching and learning -> MCAS -> test schedule

Is Earth and Space Science Still Out Of The Loop?

Should we encourage the DOE to develop an Earth and Space Science MCAS test for grade 9 or 10 (or 12)?

(Do we REALLY need another MCAS test?)

OR

Should we integrate Earth and Space Science topics into high school Life and Physical Sciences courses?

(so that students can still pass the STE MCAS)

OR

Only ask Earth and Space Science questions at the middle school level?

A Top Ten List for Studying Weather and Climate

1. There are weather and climate related questions on MCAS tests.

2. It would be nice to understand a televised weather report.

3. Creating a real-world context should not be a stretch. Using weather and climate as the real-world context means that we study what we experience on a daily basis.

4. Students need to develop an understanding of how we know what we know. When does something a scientific principle or explanation have that "The Ring of Truth"?

5. Students need to develop their powers of observation and use those observations to experience the "scientific method". A hypothesis is not a wild guess.

6. Students need to develop an appreciation for the practical application of scientific principles.

7. Students need to be involved in both short term and long term experimentation.

8.

9.

10.

What Are The Common Weather and Climate Standards?

Temperature
Barometric pressure
Wind Speed and Direction
Relative Humidity
Dew Point
Wind Chill
Heat Index
Heating Degree-Days
Cooling degree-Days

So, how many times do they need to repeat the weather forecast?

http://www.wunderground.com/

How Arbitrary Are Scientific Standards?

The Meter and the Prime Meridian
Grams and Kilograms - Mass - vs - Weight
The September Equinox and the second
Calories and calories - is heat a verb or a noun?
The Newton and The number 1

STEM Connections

The Chapter One MKS and CGS measurement system stuff.

It's National Metric Week!

http://lamar.colostate.edu/~hillger/#education

What does the UMass Mabon celebration have to do with times standards?

http://www.umass.edu/

http://www.doe.mass.edu/

Educator Services -> teaching and learning -> MCAS -> released test items -> Spring 2004 -> SET Grade 8 -> question 26

Temperature Standards

Guiding Principle III (page 7)

"Science and technology/engineering are integrally related to mathematics."

Activity Option: Design a Temperature Scale

STEM Connections

- Chemistry - Celsius and Kelvin scales
- Mathematics - Deriving Equations to Convert Temperatures

How were the Fahrenheit standards established?

http://mathforum.org/library/drmath/view/52561.html

The Highs and Lows of September:

Using the kinetic molecular theory, explain the relationship between pressure and volume (Boyle's law), volume and temperature (Charles' law), and the number of particles in a gas sample (Avogadro's hypothesis). Chemistry (page 46)

Activity Options:

- Water Barometer
- The Air Pusher
- The Can Crusher
- Feel the pressure of a pascal

STEM Connections

- Biology: Blood pressure, lungs and the middle ear
- Chemistry - Standard pressure, dimensional analysis
- Physics - vector analysis of the water barometer activity, hurricane vectors, dimensional analysis
- Technology/Engineering - Building weather instruments, HVAC, tire pressure, etc.
- Mathematics - The Power of Proportions

The ecologically safe liquid barometer:

http://www.allivanmktg.com/schools.htm

The middle ear barometer:

http://www.earaces.com/anatomy.htm

D. Air Pressure Standards

Meteorologists use barometers to measure air pressure in inches of mercury. Chemists use manometers to measure gas pressure and arbitrarily have decided that standard atmospheric pressure is equal to 760 mm of mercury. The variety of pressure units is shown in the following table.

Unit	Abbreviation	Unit equivalent to 1 atm
1 Atmosphere	atm	1 atm
inches of mercury	in. Hg	29.92 in. Hg
millimeters of water	mm H_2O	10,336 mm
millimeters of mercury	mm Hg	760 mm Hg
millibars	mb	1013.2 mb
Torr	torr	760 torr
pounds per square inch	lb / in_2 (psi)	14.7 lb / in^2
Pascal	Pa	101,325 Pa
kiloPascals	kPa	101.325 kPa

Question 11: How would you convert a pressure measured in inches of water in a water barometer into inches of mercury? Show that calculation using the data from the water barometer demonstration.

Question 12: What is the percent difference between the value calculated in Question 11 and the barometric pressure obtained from a weather station?

Question 13: What are some sources of error in the water barometer value?

Question 14: What is the weather station's barometric pressure today:

a. in millimeters of mercury

b. in kiloPascals

Design a Demonstration

One pascal is a pressure of one Newton per square meter. Design a demonstration of one pascal of pressure.

Adiabatic Phase Changes

Describe the four states of matter (solid, liquid, gas, plasma) in terms of energy, particle motion, and phase transition. Chemistry (page 45)

A SET learning Standard Example that does not apply: Recognize that heat is a form of energy and that temperature change results from adding or taking away heat from a system. Physical Science (page 44)

Activity Option: The Two Liter Cloud Machine

STEM Connections

- Chemistry: Phase Changes
- Physics: Thermodynamics
- Technology/Engineering: HVAC

Detecting adiabatic heating:

http://www.fas.harvard.edu/~scdiroff/lds/ThermalPhysics/AdiabaticHeating/AdiabaticHeating.html

Combining Standards

It's Not the Heat, It's the Humidity

OR

It's Not the Cold; It's the Lack of Humidity

Explain how air temperature, moisture, wind speed and direction, and precipitation make up the weather in a particular place and time. Earth and Space Science (Grades 3 - 5 on page 14)

Activity Option: Combining Standards

- Heat Index
- Dew Point
- Temperature Perception
- Wind Chill

STEM Connections

- Earth Science - Clouds, Fog, Frost, and Dew
- Biology - Your body's evaporative cooling system, surface and core temperatures, frostbite
- Chemistry - phase change, Avogadro's Hypothesis (Is humid air more dense or less dense than dry air?)
- Technology/Engineering - heat pumps

http://www.crh.noaa.gov/pub/heat.htm

http://weather.unisys.com/surface/sfc_con_dewp.html

http://www.erh.noaa.gov/er/iln/tables.htm

http://observe.arc.nasa.gov/nasa/earth/wind_chill/chill_home.html

An Activity Session

The Cloud Machine
Design a Temperature Scale
Water Barometer
The Air Pusher
The Can Crusher
Feel the Pressure
The Heat Index
Feel The Chill

The Two Seasons

January 1st to December 31st

And

July 1st to June 30th

Explain how environmental conditions influence heating and cooling of buildings and automobiles.
Technology/Engineering (page 60)

Activity Option: How Cool Was It?

STEM Connections

- Earth Science: Climate Studies, The Reasons for Seasons
- Biology: Growing Seasons
- Technology/Engineering: Thermal Systems
- Mathematics: Statistical Analysis

From the USA Today web site: Select NCDC Data Table. Then select heating or cooling degree days,

http://www.usatoday.com/weather/walm0.htm

For a PDF file with detailed, state by state data

http://www.ncdc.noaa.gov/oa/documentlibrary/hcs/hcs.html#overview5-1

Is It Colder In The Mountains Or In The Winter?

For cool NCDC maps elect ANN for “lower” 48 states or select Hawaii or Alaska:

http://www.ncdc.noaa.gov/oa/climate/normals/assessments.html

For more maps select:

http://lwf.ncdc.noaa.gov/oa/documentlibrary/clim81supp3/clim81.html

Energy on the Move

Differentiate among radiation, conduction, and convection, the three mechanisms by which heat is transferred through the earth's system. Earth and Space Science (Grades 6 - 8 on page 17) and

- **a learning standard for Earth and Space Science for Grades 9 or 10**
- **a description of a broad concept for Physics in Grades 9 or 10.**
- **two learning standards for Technology/Engineering**

Activity Options:

- **Radiation: "The Heat Race"**
- **Conduction: "Hot Rod"**
- **Convection: "Smoke Box"**

Conduction, convection, and radiation:

http://www.mansfieldct.org/schools/mms/staff/hand/convcondrad.htm

Is conduction really radiation from one atom to another?

http://www.efunda.com/formulae/heat_transfer/radiation/overview_rad.cfm

How is Earth heated by the sun?

http://wps.prenhall.com/esm_lutgens_atmosphere_8/0%2C6585%2C263598-%2C00.html

items 8 and 14 on the Grade 10 Technology/Engineering pilot test:

http://www.doe.mass.edu/

Designs for Weather and Climate

How many solar collectors will students build?

They don't seem to resist doing it repeatedly.

SET Learning Standard Examples (Technology/Engineering, pages 54 and 55)

- **Given a design task, identify appropriate materials based on specific properties and characteristics.**)
- **Identify and explain the steps of the engineering design process.**
- **Describe and explain the purpose of a given prototype.**
- **Identify the five elements of a universal systems model; goal, inputs, processes, outputs, and feedback.**

Activity Option: The Solar Design Challenge

Solar Insolation

http://www.wattsun.com/resources/insolation_maps/flat_plate.html#mar

Design Details

http://www.greenbuilder.com/Sourcebook/PassSolGuide3.html

Velocity, Frequency, and Wavelength

SET Learning Standard Examples (Physics pages 48 and 49)

- **Recognize the measurable properties of waves (e.g., velocity, frequency, wavelength) and explain the relationship among them.**
- **Distinguish between mechanical and electromagnetic waves.**
- **Explain how the various wavelengths in the electromagnetic spectrum have many useful applications such as radio, television, microwave appliances, and cellular telephones.**

Activity Options: Wave Characteristics

- Velocity, frequency, and wavelength
- Analyze Electromagnetic radiation
- E, h, f, c, n, and λ

STEM Connections

- Chemistry: The Bohr Model of the atom, The Flame Test
- Physics: Electromagnetism
- Technology/Engineering: Communication Technologies

Mechanical waves

http://members.aol.com/nicholashl/waves/movingwaves.html

Standing waves

http://www.glenbrook.k12.il.us/gbssci/phys/mmedia/waves/swf.html

Electromagnetic waves

http://www.colorado.edu/physics/2000/waves_particles/

Is It Really Relative?

Provide examples of how the unequal heating of the earth and the Coriolis Effect influence global circulation patterns, and show their impact on Massachusetts weather and climate, e.g., convection cells, trade winds, Westerlies, polar easterlies, and the inclination of the axis of the earth cause the earth's seasonal variations (equinoxes and solstices). Earth and Space Science (Grades 9 or 10 on page 21)

Activity Option: The Coriolis Effect

STEM Connections

- Earth and Space Science: Earth's Motions, Global Wind Patterns (e.g. El Nino)
- Physics: Frames of Reference, Relativity

The simple explanation:

http://zebu.uoregon.edu/~js/glossary/coriolis_effect.html

An Interactive web site:

http://www.eoascientific.com/campus/earth/multimedia/coriolis/view_interactive

Is the Coriolis Force a fictitious force?

http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/fw/crls.rxml

http://www.ems.psu.edu/%7Efraser/Bad/BadFAQ/BadCoriolisFAQ.html

Global Wind Patterns

http://www.pbs.org/wgbh/nova/elnino/now/mapping13llarge.html

An Activity Session

Heating and Cooling Seasons
Energy On The Move
The Solar Design Challenge
Wave Characteristics
The Coriolis Effect

Inquiry and Experimentation

"Scientific inquiry and experimentation should not be taught or tested as separate, stand-alone skills. Rather, opportunities for inquiry and experimentation should arise within a well-planned curriculum in the domains of science. They should be assessed through examples drawn from the life, physical, and earth and space science standards so that it is clear to students that in science, *what* is known does not stand separate from *how* it is known."

Activity Option: A Weather Diary

Weather Proverbs

http://www.boatsafe.com/nauticalknowhow/weather_proverbs.htm

A STEM Ed Project

The Guide to Teaching Renewable Energy and Global Warming

www.mtpc.org/2004dev/cleanenergy/curriculum/about.htm

Earth Science and Licensure

Subject Matter Knowledge Requirements for Teachers

www.doe.mass.edu/lawsregs/603cmr7/7.06.html

Professional Standards for Teachers (2.a.7, 2.b.1.c)

www.doe.mass.edu/lawsregs/603cmr7/7.08.html

Massachusetts Test for Educator Licensure in Earth Science

www.ntel.nesinc.com/PDFs/MTEL_fld14TIB.pdf

The Fine Print

Regulations for Educator Licensure and Preparation Program Approval

URL: http://www.doe.mass.edu/lawsregs/603cmr7/7.06.html

7.06: Subject Matter Knowledge Requirements for Teachers

(6) Earth Science (Levels: 5-8; 8-12)

(b) Oceanography.
(c) Astronomy.
(d) Environmental biology, physics, and chemistry.
(e) Meteorology.
(f) Related aspects of chemistry, physics, biology, and mathematics.
(g) Engineering and technical applications of earth science.
(i) Methods of research in the sciences, including laboratory techniques and the use of computers.

(19) Middle School: Mathematics/Science (Levels: 5-8)

(a)General Science.
1.Intermediate knowledge of biology, chemistry, physics, earth/space science, and related mathematics.
3.Methods of research in the sciences, including laboratory techniques and the use of computers.

(29) Technology/Engineering (Levels: 5-12)

(a) Nature of engineering and technology systems.
(b) Engineering concepts in specific fields: manufacturing, construction, communication, power, energy, and transportation technologies.
(c) Engineering design and technology development process.
(d) How to use tools, machinery, and materials properly and safely.
(e) Environmental effects of engineering/technology.
(f) Skill in technical reading and writing.
(g)Requisite topics in mathematics and physical sciences.

Dear Commissioner