Virtual Learning Magnet Physics

Unique VLM Approach

1. How can the study of acceleration explain how aircraft and spacecraft produce and/or change their motion? (Kinematics)
   Textbook correlations: to be determined
   SPACEMATH ACTIVITIES: http://spacemath.gsfc.nasa.gov/
   A. CONSTANT SPEED ONE-DIMENSIONAL MOTION
      i. Experimentation and the Scientific Method
         Lesson – What is physics all about?
         Read: "What is Physics?" and "How do we go about studying Physics?"
      ii. Measurement and fundamental units
         http://www.nasa.gov/mov/178726main_072_ksnn_3-5_meter_cap.mov
         Spacemath: Problem 48: Scientific Notation – Astronomical Perspective
         Spacemath: Problem 82: Are U Nuts?
         Spacemath: Problem 109: Scientific Notation I
         Spacemath: Problem 110: Scientific Notation II
         Spacemath: Problem 111: Scientific Notation III
         Test – Readiness assessment
      iii. Constant speed motion – observe/demonstrate
         Lesson – How do we design an experiment?
         INTERACTIVE DISCUSSION – How can we design an experiment to determine the relationships associated with constant speed motion?
         Read: "Laboratory Investigations in Physics"
         LAB – using one of the NASA video clips of constant speed motion, collect data. (Help! – Clip should involve some vehicle or object moving at constant speed over a significant distance filmed by a camera that isn't moving or against a backdrop that can be used to measure the change in location. It needs to be able to be paused or advanced frame-by-frame so that time measurements can be taken. A clock superimposed on the screen would be perfect.)
      iv. Relationships between variables
         Lesson – How do we establish the relationship between variables? What is the difference between independent and dependent variables?
         Read: "What are variables and how are they classified?" and "How can variables be related?"
      v. Graphing of data
         Lesson – How do we set up graphs of data? How do we use computer graphing programs (such as Graphical Analysis or Logger Pro)?
         Read: "How do we construct graphs of data in physics?" and "What is the unique role of TIME in the study of physics?"
         Lab (cont'd) – graph data
      vi. Interpretation of graphs

Lesson – What are the four familiar graph patterns? What does the shape of a graph say about the relationship between variables? How can we reduce graphs to formulas? What is the physical meaning of the slope of certain graphs? How do we determine the unit of the slope? How do we use slope to define new variables in physics?
Read: "How do we interpret the graphs we create in physics?" and "What does this process say about cause-and-effect?"
Spacemath: Problem 152: the Hubble Law
Lab (cont'd) – analyze graph, define speed

vii. Where do we proceed from here?
Read: "What do we do after we discover a formula?" and "How do formulas become theories?"
Spacemath: Problem 45: Theories, Facts, Beliefs
Lab (cont'd) – complete and submit lab report
Problem Set #1 – Constant speed motion
Spacemath: Problem 53: Astronomy – A moving Experience

B. CONSTANTLY ACCELERATED ONE-DIMENSIONAL MOTION

i. Distance-time relationship
ii. Speed-time relationship
INTERACTIVE DISCUSSION – How can we design an experiment to determine the relationships associated with constantly accelerated motion?
LAB – collect and graph data on constantly accelerating motion – graph data – analyze graph – define acceleration – submit lab report. (Clip should involve some vehicle or object moving with constant acceleration, either speeding up or slowing down, over a significant distance filmed by a camera that isn't moving or against a backdrop that can be used to measure the change in location. See comments from constant speed lab above.)
iii. Acceleration – examples: (I need help finding video clips of rocket sleds, shuttle launch, carrier catapult, etc. Ability to take actual measurements from clip a definite plus.)
iv. Freefall and Galileo's Law of Falling Bodies
LAB – collect and graph data on freefall motion – analyze data – submit lab report. (Help – need footage of some object in freefall over a significant distance. See comments on constant speed motion lab.)
LAB – using NASA video clip of Apollo 15 hammer-and-feather drop, complete lab exercise (see accompanying lab exercise) on freefall on the moon – compare freefall on earth with freefall on the moon
Problem Set #2 – Constantly accelerated one-dimensional motion

C. TWO-DIMENSIONAL MOTION

i. Vectors, vector components, and vector sums
ii. Projectiles ("Vomit Comet")
INTERACTIVE DISCUSSION – How can we design an experiment to determine the difference between the horizontal and vertical motions of a projectile?
iii. Independence of horizontal and vertical components

LAB – video projectile motion – analyze data – compare horizontal and vertical motions – submit lab report
EXTENSION – compare with the path of a rocket (not freefall)
Problem Set #3 – Two-dimensional projectile motion

D. RELATIVISTIC MOTION
   i. The speed of light (history, current beliefs)
   ii. Postulates of Relativity
   iii. Relativistic effects on length, mass, and time
   INTERACTIVE DISCUSSION – How is relativistic motion different from the non-relativistic motion we have studied so far? What is "counterintuitive" about it? What are its implications for long-range space travel?
   iv. Additivity of velocities (as compared with Newtonian motion)
   Problem Set #4 – Relativistic motion
   INTERACTIVE DISCUSSION – What are all the different ways that the study of kinematics (motion) plays itself out in flight and the exploration of space?

2. How can the study of Newton's Laws of Motion explain how forces produce acceleration in aircraft and spacecraft? (Mechanics)

Textbook correlations: to be determined

Resources:
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Introduction_to_Newtons_Laws.html
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/The_Law_of_Inertia.html
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Force_Equals_Mass_Times.html
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/The_Law_of_Action_and_Reaction.html
http://www.nasa.gov/mov/192446main_016_intro_newton_laws.mov
http://www.nasa.gov/mov/192447main_017_law_of_inertia.mov
http://www.nasa.gov/mov/192448main_018_force_equals_mass_time.mov
http://www.nasa.gov/mov/192449main_019_law_of_action.mov
http://www.nasa.gov/mov/194144main_022_drag.mov
http://www.nasa.gov/mov/194159main_023_thrust.mov

A. FORCES, FORCE DIAGRAMS, AND NET FORCE
   i. Contact forces vs. forces-at-a-distance (normal force and friction)
   ii. Free-body diagrams (airplane in level flight, shuttle launch, floating astronauts)
   Problem Set #5 – Net Force

B. NEWTON'S SECOND LAW
   i. Relation ship between acceleration, mass, and net force
   INTERACTIVE DISCUSSION – How can we design an experiment to determine the relationships between acceleration, mass, and net force?

LAB – model rocket launch – collect and analyze data
EXTENSION – compare with data from Apollo launch

ii. Weight as a force (video of astronauts on Moon, astronauts floating)
iii. Galileo's Law of Falling Bodies revisited
iv. Applications
Problem Set #6 – Newton's Second Law

C. NEWTON'S FIRST AND THIRD LAWS
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Balloon_Staging.html
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Space.Shuttle.Glider.html
i. Inertia and mass (weightless motion, docking)
ii. First law as special case of Second Law
iii. Examples of Newton's First Law
iv. Reaction forces as matched pairs
v. Examples of Newton's Third Law
http://www.nasa.gov/mov/178695main_043_ksnn_3-5_rtf_02_cap.mov
vi. Applications (shuttle and Apollo launches, return from orbit, weightless motion)
Problem Set #7 – Newton's First and Third

D. TORQUE AND ROTATION
i. Center of mass
ii. Torque as an off-center force (capsule maneuvering, shuttle engines, "the Twang")
INTERACTIVE DISCUSSION – What is the difference between translation and rotation? What are some of the real-world applications of the difference in these two ways of applying a force to an object?
iii. Rotational statics
LAB – Balanced Torques (?)
http://brainbites.nasa.gov/bolt/
iv. Rotational dynamics
Problem Set #8 – Torque and Rotation

3. How does gravity, the universal and fundamental force related to matter, explain motion in our universe? (Gravity)

Textbook correlations: to be determined

Resources:
http://www.nasa.gov/mov/196832main_068_Retrospective_Gemini.mov
http://www.nasa.gov/mov/196757main_047_The_Planets.mov
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Calculating_Time_in_Space.html

A. CIRCULAR MOTION
i. Circular motion, centripetal force and centripetal acceleration (Help – need video of astronauts training in centrifuge with ability to measure rate of revolution and estimate radius of circle → estimate "g" forces)
http://space.jaxa.jp/movie/20080411_kaguya_movie01_e.html (Earthrise)
http://www.jaxa.jp/press/2008/04/20080411_kaguya_e.html
LAB – Circular Motion (?)
Problem Set #9 – Circular Motion

B. UNIVERSAL GRAVITATION AND ORBITAL MECHANICS
   i. Newton's Law of Universal Gravitation (Moon orbit)
   ii. Gravitational field strength (astronauts on Moon)
   iii. Orbits as circular motion (shots from orbit)
   http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/How_Do_We_Stay_in_Space.html
   http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Why_Do_Astronauts_Float.html
   http://www.nasa.gov/mov/178693main_041_ksnn_3-5_float_cap.mov
   http://www.nasa.gov/mov/194267main_036_gravity_on_earth.mov
   INTERACTIVE DISCUSSION – How does an understanding of circular motion and gravity change your view of what it means for an orbiting astronaut to be "weightless?"
   iv. Kepler's Laws of Planetary Motion and non-circular orbits (Mars)
   http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/The_Planets.html
   Spacemath: Problem 137: Black Holes – Part V
   v. Escape Velocity
   Problem Set #10 – Gravity and Orbits

4. How does the conservation of two important physical entities, energy and momentum, explain the actions and interactions of objects on earth, in orbit, and throughout the universe? (Energy and Momentum)

Textbook correlations: to be determined

Resources:
http://www.nasa.gov/mov/194139main_021_lift_and_rate.mov

A. WORK, ENERGY, AND POWER
   i. Definition of work
   ii. Definition of energy
   http://www.nasa.gov/mov/178701main_049_ksnn_3-5_go_cap.mov
   iii. Work done against gravity (gravitational potential energy) (launch)
   iv. Work-energy theorem and kinetic energy
   INTERACTIVE DISCUSSION – So what IS energy? What role does it play in our daily lives? What will the next technological revolution (ET – Energy Technology) look like? Is our energy outlook bright or dim?
   Spacemath: Problem 117: SOHO – CME Kinetic Energy and Mass
   v. Conservation of mechanical energy
   LAB – Conservation of Energy (?)
   vi. Relativity revisited – mass-energy equivalence ($E = mc^2$)
   Problem Set #11 – Work, Energy, Power

B. IMPULSE AND MOMENTUM
   i. Definition of momentum
   http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Angular_Momentum_Inertia.html
   ii. Impulse and the impulse-momentum relationship (shuttle launch)
   iii. Collisions and conservation of momentum (docking, weightless motion)

INTERACTIVE DISCUSSION – What do all collisions have in common? What sports are nothing more than Conservation of Momentum physics lab exercises?

LAB – Conservation of Momentum (?)

iv. Elastic vs. inelastic collisions

Problem Set #12 – Impulse, Momentum, Collisions

5. How can the study of the properties, production, flow, and distribution of heat as a form of energy explain the operation of aircraft, rockets, and most forms of modern machinery and transportation? (Thermodynamics)

Textbook correlations: to be determined

A. THERMAL PHYSICS
   i. Temperature
   ii. Heat and internal energy
   iii. Heat and temperature change
   iv. Phase changes (ice on Apollo and shuttle)
   v. Heat transfer
   vi. Kinetic Theory and the Ideal gas law

B. HEAT ENGINES
   i. Zeroth and First laws of thermodynamics
   ii. Second law and entropy
   iii. Heat engines and thermodynamic cycles
   iv. Applications (refrigeration, cryogenic fuels)

   Problem Set #13 – Thermodynamics and Heat Engines

C. FLUID PROPERTIES
   i. Density and pressure
   ii. Pressure vs. depth in liquids and gases
   iii. Pascal's Principle
   iv. Buoyancy and Archimedes' Principle

D. FLUID DYNAMICS
   i. Equation of continuity (rocket engines)
   ii. Viscosity
   iii. Bernoulli's Principle

   LAB – model airplanes

   iv. Applications (flight)

   Problem Set #14 – Fluids and Fluid Dynamics

6. How can an understanding of the fundamental wave behaviors exemplified by sound and light explain communication in our modern world? (Waves)

Textbook correlations: to be determined

A. BASIC WAVE PROPERTIES (including superposition, resonance, and standing waves)
B. SIMPLE HARMONIC MOTION
C. SOUND

http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Variables_That_Affect_the_Speed.html

http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Variables_That_Affect_the_Speed.html

http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Demonstrating_the_Difference.html
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Understanding_Sonic_Booms.html
Problem Set #15 – Waves and Sound

D. ELECTROMAGNETIC RADIATION AND THE ELECTROMAGNETIC SPECTRUM
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Radar_Radio_Waves.html
http://brainbites.nasa.gov/callmars

E. REFLECTION AND MIRRORS (OPTICS)
LAB – Reflecting Telescopes (Hubble)

F. REFRACTION AND LENSES (OPTICS)
http://www.nasa.gov/mov/178713main_059_ksnn_3-5_rainbows_cap.mov
LAB – Behavior of Lenses
Problem Set #16 – Light and Optics

G. DIFFRACTION, DISPERSION, INTERFERENCE, POLARIZATION, DOPPLER EFFECT
http://www.nasa.gov/mov/178706main_054_ksnn_3-5_sky_cap.mov
Spacemath: Problem 50: Measuring the Speed of a Galaxy
Spacemath: Problem 54: Exploring Distant Galaxies

7. How can an understanding of the fundamental behaviors of charged particles and the inseparability of electrical and magnetic phenomena explain the rise of industry and the nature of our post-industrial world? (Electricity & Magnetism)

Textbook correlations: to be determined

A. CHARGED PARTICLES AND ELECTRIC FORCE (Coulomb's Law)
http://www.nasa.gov/mov/178702main_050_ksnn_3-5_lightning_cap.mov

B. ELECTRIC FIELDS

C. ELECTRIC POTENTIAL ENERGY, ELECTRIC POTENTIAL, AND CAPACITANCE
Spacemath: Problem 14 Kinetic Energy and Particle Motion
Problem Set #17 – Electrostatics

D. ELECTRIC CURRENTS AND CIRCUITRY (Series, parallel)
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/What_Is_Electricity.html
LAB – simple DC circuitry
LAB – photovoltaic cells
Problem Set #18 – Electric Currents

E. MAGNETISM, ELECTROMAGNETISM AND ELECTROMAGNETIC INDUCTION
http://www.nasa.gov/mov/178703main_051_ksnn_3-5_electromagnet_cap.mov
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/How_Tethered_Technology_Is_Used.html
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Earths_Role_as_an_Electromagnet.html

http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Experimenting_With_Electromagnets.html
Spacemath: Problem 19: An Application of the Pythagorean Theorem

F. ELECTRIC MOTORS
LAB – build a small electric motor

G. ELECTRIC POWER GENERATION
Problem Set #19 – Electromagnetism and Electromagnetic Induction

8. What is the role in our modern world of the remaining two fundamental forces, both found in the nucleus? (Nuclear Physics)

Textbook correlations: to be determined

A. REVIEW OF ATOMIC STRUCTURE
B. QUANTUM THEORY AND ATOMIC ENERGY LEVELS
C. NUCLEAR BINDING ENERGY
D. RADIOACTIVITY AND HALF-LIFE
Spacemath: Problem 67: Unit Conversion Exercises
Spacemath: Problem 68: An Introduction to Space Radiation
Spacemath: Problem 70: Radiation Dosages at Mars
Spacemath: Problem 71: Van Allen Radiation Belts
Spacemath: Problem 76: Radon Gas in the Basement
E. FISSION AND FUSION
Problem Set #20 – Nuclear Physics