1. Tutorial lab info: it *will* be open during reading days and finals, but the TAs have their own exams to study for and take so staffing may vary significantly from the regular schedule.
2. Final exam:
   a. Take in Testing Center anytime during finals week
      → See Testing Center website for their exact schedule
   b. Will have ~40 problems
   c. ~10 problems on new stuff; rest is cumulative
   d. Average time should be 2-2.5 hours
      i. 4 hr time limit
   e. Last year's median = 75; this year's exam is a little harder, I'm shooting for 72-73.
      i. I'll curve it up to 70 if it ends up being below that
   f. No calculators, no notecards
   g. First page of exam has been posted to class website— that tells you which formulas will be given on exam.
   h. What to study (roughly in order of importance)
      i. Midterm exams
      ii. Homework (all of them, but especially the last three assignments)
      iii. Class notes
      iv. Warmup quizzes
      v. Last year's final
      vi. Textbook
3. Two TA-led final exam reviews, room still TBA:
   a. Thurs 7 – 9 pm
   b. Fri 1 – 3 pm
4. Deadlines:
   a. All extra credit must be turned in to your regular homework boxes by midnight tonight!
   b. Instructor/course ratings must be done by Sat Dec 13
      http://studentratings.byu.edu
   c. All late computer homework must be done by midnight Fri Dec 19 (last day of finals)

Formulas Review: Chap 13-14

Definitions and Fundamental Laws
Final exam: you will be expected to know these on your own

$$f = \frac{1}{T}, \ \omega = 2\pi f, \ T = \frac{2\pi}{\omega}$$

Wave speed $v = f\lambda$

Intensity $I = P/A$

New stuff, but not quite as basic
Final exam: I will give you these (but maybe without the "tags")

spring $\omega = \sqrt{\frac{k}{m}}, \ T = 2\pi\sqrt{\frac{m}{k}}$

pendulum $\omega = \sqrt{\frac{g}{L}}, \ T = 2\pi\sqrt{\frac{L}{g}}$

wave speed $v = \sqrt{\frac{T}{\mu}}, \mu = m/L \quad v = \sqrt{\frac{B}{\rho}} \quad v = \sqrt{\frac{Y}{\rho}}$

v_{air} = 343 m/s, unless otherwise specified

$A_{sphere} = 4\pi r^2$

decibels $\beta = 10\log\left(\frac{I}{I_0}\right) \quad I_0 = 10^{-12}$ W/m^2

Doppler: $f' = f\frac{v \pm v_o}{v \pm v_s}$

standing waves: $L = \frac{n}{2}\lambda \quad n = 1,2,3,... \qquad L = \frac{n}{4}\lambda \quad n = 1,3,5,...$

Things which *you* might consider to be formulas
(but I don't really, so I won't give them to you on exam)

- What A and ω stand for in the equation for a sinusoidal wave, i.e. $x = A\cos(\omega t)$
- How to solve for I in the decibel formula
- How to choose +/- signs in Doppler formula
- How to use e.g. $L = \frac{n}{2}\lambda$ formula to figure out frequency of a harmonic
- (I'm sure there are more…)

Review of important concepts, Chap 13-14

1. Sinusoidal Oscillations $A\sin(\omega t)$ or $A\cos(\omega t)$
   a. Amplitude
   b. Period vs. frequency vs. angular frequency
      i. $f = \dfrac{1}{T}$, $\omega = 2\pi f$, $T = \dfrac{2\pi}{\omega}$
   c. Simple harmonic motion
      i. spring: $\omega = \sqrt{\dfrac{k}{m}}$
      ii. pendulum: $\omega = \sqrt{\dfrac{g}{L}}$
         1. When does this hold true?

2. Waves: oscillations that transport energy
   a. Often sinusoidal in space and in time
   b. Longitudinal vs. transverse
   c. Reflections…when does an upward pulse reflect off downward?
   d. Superposition/interference
   e. Speed, wavelength, frequency: $v = f\,\lambda$
   f. Equations for wave speed in different materials
      i. sqrt(force-like quantity / mass-like quantity)

3. Sound waves
   a. Intensity of a wave $I = P/A$
      i. Spherical waves, $A = 4\pi r^2$

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   b. Decibel scale (sound): $\beta = 10\log\left(\dfrac{I}{I_0}\right)$ $I_0 = 10^{-12}$ W/m^2
      i. +10 to dB number = ×10 to the intensity
   c. Doppler effect: $f' = f\,\dfrac{v \pm v_0}{v \pm v_S}$
      i. If lady (observer) is moving towards baker:
         1. numerator + (because freq increases)
      ii. If baker (source) is moving towards lady:
         1. denominator – (because freq increases)
      iii. If moving *away*, use opposite sign.

4. Interference/superposition of waves
   a. Constructive/destructive interference
      i. Waves off by λ vs. waves off by $\lambda/2$
   b. Standing waves
      i. Vocabulary: nodes vs. antinodes
      ii. Closed-closed or open-open
         1. L = 1/2 λ, 2/2 λ, 3/2 λ, … from pictures
         2. Summary: $L = \dfrac{n}{2}\lambda$ $n = 1, 2, 3, ...$
      iii. Open-closed
         1. L = 1/4 λ, 3/4 λ, 5/4 λ, … from pictures
         2. Summary: $L = \dfrac{n}{4}\lambda$ $n = 1, 3, 5, ...$
      iv. Freq of nth harmonic = wavespeed ÷ λ of nth harmonic
   c. Beats: $f_{beat} = |f_1 - f_2|$

Some HW problems (missed by many):
HW 20-1. A 5.56-g object is suspended from a cylindrical sample of collagen 3.58 cm long and 2.12 mm in diameter. If the object vibrates up and down with a frequency of 30.3 Hz, with is the Young's modulus of the collagen?

Answer: 2.04E06

HW 21-4. A stereo speaker emits sound waves with a power output of 26.6 W. (a) Find the intensity 10.5 m from the source. (Assume that the sound is emitted uniformly in all directions from the speaker.) (b) Find the intensity level, in decibels, at this distance. (c) At what distance would you experience the sound at the threshold of pain, 120 dB?

Answers: 0.0192 W/m^2, 102.8 dB, 1.45 m

HW 22-2. A pair of speakers separated by 0.76 m are driven by the same oscillator at a frequency of 690 Hz. An observer, originally positioned at one of the speakers, begins to walk along a line perpendicular to the line joining the two speakers. (a) How far must the observer walk before reaching a relative maximum in intensity? (b) How far will the observer be from the speaker when the first relative minimum is detected in the intensity? (Take the speed of sound to be 345 m/s.)

Answers: 0.33 m, 1.03 m

HW 22-5. Two identical mandolin strings under 205.6 N of tension are sounding tones with fundamental frequencies of 523 Hz. The peg of one string slips slightly, and the tension in it drops to 196.7 N. How many beats per second are heard?

Answer: 11.4

Some clicker quizzes

Clicker quiz 1: You hear a 70 dB sound. After a while, the sound has its *intensity* increased by a factor of 100. The new decibel-level will be_____ dB.

    A: 50   B: 60   C: 80   D: 90   E: 100

Clicker quiz 2: When people stand up and sit down in a stadium to perform the "wave", this is an example of what kind of wave?

    A. Longitudinal
    B. Circular
    C. Simple Harmonic
    D. Transverse

Clicker quiz 3: A mass on a spring oscillates with a certain frequency. The mass is removed, and a mass weighing 9 times as much is put on the same spring. What is the ratio of the new frequency to the old frequency? (f_{new}/f_{old} = _____)

    a. 1/81
    b. 1/9
    c. 1/6
    d. 1/3
    e. 1

More worked problems (in exam format)

A 70 dB sound is coming out spherically from a speaker that puts out 0.5 Watts in sound power. How far away from the speaker are you? _____ m

  a. $\sqrt{\dfrac{0.5}{\left(10^{-5}\right)4\pi}}$

  b. $\sqrt{\dfrac{0.5}{\left(10^{-7}\right)2\pi}}$

  c. $\sqrt{\dfrac{0.5}{\left(10^{-7}\right)4\pi}}$

  d. $\dfrac{0.5}{\left(10^{-5}\right)2\pi}$

  e. $\dfrac{0.5}{\left(10^{-5}\right)4\pi}$

  f. none of the above

Note: On the problem-type questions, I will only include "none of the above" as a fail-safe against my own solution being wrong. I won't intentionally make that be the answer. On the conceptual questions, however, that won't necessarily be the case.

Answer: A

A train whistle gives off a tone of 500 Hz when the train is still. What frequency will a person at the station hear as the train nears the station at a speed of 100 m/s? (Use 300 m/s as the speed of sound.)
   a. 333 Hz
   b. 375 Hz
   c. 500 Hz
   d. 667 Hz
   e. 750 Hz
   f. none of the above

Answer: E

Tarzan, standing on a tree branch, grabs a vine (length L) and swings on it. Approximately how long will it take him to go from his initial perch to the bottom of his swing where he is moving most quickly? (His initial angle is small.)

   a. $\dfrac{\pi}{2}\sqrt{\dfrac{L}{g}}$

   b. $\pi\sqrt{\dfrac{L}{g}}$

   c. $2\pi\sqrt{\dfrac{L}{g}}$

   d. $\sqrt{\dfrac{2L}{g}}$

   e. $2\sqrt{\dfrac{L}{g}}$

How would this answer change if Tarzan "pushes off" from his branch?
   a. time would be longer
   b. time would be shorter
   c. time would not change

Answers: A, B

A standing wave is set up in a 2.5 m length string fixed at both ends. The string vibrates in 5 distinct segments when driven at 100 Hz. (That is, the vibration has 5 anti-nodes.) What is the fundamental frequency of the string?
   a. 20 Hz
   b. 25 Hz
   c. 50 Hz
   d. 75 Hz
   e. 100 Hz

What is the speed of the waves on the string?
   a. 10 m/s
   b. 20 m/s
   c. 33 m/s
   d. 100 m/s
   e. 200 m/s

Answers: A, D

Physics 105: What was this class all about, anyway?

1. The universe makes sense!
2. The universe can be described mathematically. "Mathematics is the language of physics."
      a. Algebra. Example: Kinematics equations
            i. Position
            ii. Velocity
            iii. Acceleration
      b. Geometry. Example: Area/volume of sphere
      c. Trigonometry. Examples: Vectors, oscillations
      d. Logarithms. Example: decibel scale
      e. Calculus (not too much in this course)
3. Natural phenomena follow natural laws. Examples:
      a. Newton's Laws of Motion
            i. Newton 1: Inertia
            ii. Newton 2: Forces
                  1. Weight, normal, tension, friction, etc.
            iii. Newton 3: Partner forces
      b. Newton's Law of Gravity
            i. Kepler's Laws
      c. Conservation of energy
            i. including work, which can add to/take away from energy of a system
                  1. Work is done when a force is applied over a distance
            ii. including rotational energy
            iii. including random energy: "internal energy"

1. First Law of Thermodynamics
   a. Work is done when pressure is applied with a change in volume
   b. Heat flow is a type of energy transfer
   d. Conservation of momentum (if no outside force)
   e. Conservation of angular momentum (if no outside torque)
4. Sometimes, the behavior of large numbers of objects (e.g. molecules) can be described using overall properties
   a. Ideal gas law
      i. Temperature, pressure
   b. Fluids
      i. Static: Archimedes (buoyancy)
      ii. Dynamic: Bernoulli (pressure, speed of flow)
5. Sometimes, probabilities are all we can talk about
   a. Kinetic theory→ average velocity
   b. Second Law of Thermodynamics
   c. More in quantum physics (Physics 106)
6. Matter and energy interact
   a. Radiation
   b. Waves
   c. More in electricity/magnetism (Physics 106)

What I haven't yet told you, i.e. "What else is there to learn in physics, anyway?"

1. More interaction between matter & energy (some of this in Physics 106)
   a. Electricity & Magnetism
      i. These are "fields"—forces acting at a distance, like gravity
      ii. Currents, circuit elements
      iii. Optics (electromagnetic waves)
   b. Einstein: matter/energy can be transformed into each other, $E = mc^2$
2. Einstein: Newton was wrong! (incomplete) (some of this in Physics 106)
   a. "Special relativity": Newton's Laws of Motion are flawed. Space & time are relative!
      i. …but Newton's Laws work pretty well as long as speeds are not close to speed of light
   b. "General relativity": Newton's Law of Gravity is flawed
      i. …but it works pretty well as long as mass isn't too concentrated (superhigh density)
3. Quantum physics (some of this in Physics 106)
   a. Not only is a probabilistic description useful, it's *necessary*
      i. Everything is a wave, or at least a "wave function"
   b. Uncertainty: you can't actually know the position and velocity of an object at the same time
      i. …but you can get pretty close if the mass isn't too tiny

4. Particle physics, nuclear physics
   a. Protons/neutrons composed of "quarks"
   b. Many, many other subatomic particles
      i. What kinds?
      ii. Why?
5. Physics of solids
   a. Why are solids different from each other?
   b. How can things like thermal expansion, specific heat, electrical properties, etc., be predicted?
   c. Special kinds of solids
      i. Metals
      ii. Semiconductors
      iii. Superconductors
      iv. Many more
6. Astrophysics/cosmology
   a. What did the universe look like in the past?
   b. What does the universe look like now?
   c. What will the universe look like in the future?
7. Much, much more!

Summary of the semester, from the student perspective (end of semester survey last year):

"I learned…"

Kinematics
- That x and y motions are independent of each other.
- That a bullet shot from a rifle will hit the ground at the same time as one dropped from the same height if the bullet is shot parallel to the ground (neglecting air resistance).

Gravity
- That if you have a feather and a lead ball in a vacuum, they will fall and hit the ground at the same time because gravity acts the same on them.

Inertia
- When you are in a car and it turns, the "force" you feel pushing out on you really isn't a force, rather its the force of the car on you, seeing as your body wants to keep going straight.

Friction
- That anti-lock breaks work because the static coefficient of friction is larger than the kinetic.

Partner Forces
- That Newton's Third Law explains why pushing my skis against the snow causes me to turn in the opposite direction.

Centripetal Acceleration
- Why you are "lifted" out of your seat while on a roller coaster

Satellites
- Why my dad's company launches rockets from the equator of the earth near the Christmas Islands. It is because there the earth is spinning and has some rotational energy that helps the rocket escape from earth. [Colton: also because geosynchronous orbits must go around the equator.]
- Why your satellite dish can always be pointed in the same direction.
- That satellites (including the moon!) don't fall to the ground because they are in a constant state of free-fall but are moving move forward fast enough that they always 'miss' the earth.

Torque
- Why wrenches work better than fingers!

Angular Momentum
- That conservation of angular momentum makes an ice-skater's rotation speeds up when she brings in her arms
- How the rotation of the wheel helps keep me balanced on my dirtbike.

Pressure
- That snowshoes prevent a person from sinking into the soft snow because the force on the snow is spread over a larger area—just like a person can withstand a bed of nails because the force is spread over a larger area (the total area of all of the nail points).
- Why pressure is lower at higher altitudes

- That how large a lake is doesn't affect the force on a dam, but rather how deep the lake is.
- That straws work due to atmospheric pressure and not from a "suction force." I also thought it was interesting that the longest straw that one could use would be 10 meters.
- That a hydraulic system can allow a small force to lift a heavy car.

Buoyancy
- Why a boat sinks further into the water when more people get on.
- Why it's easier to lift someone inside a swimming pool than on the outside ground.
- Why you will float better in the Great Salt Lake than in a swimming pool (greater buoyant force due to the density of the salt water).

The "Garden Hose" Principle
- Why the water shoots out of a hose faster when you put your finger over the opening.

The Bernoulli Effect
- That chimneys work better on windy days because the wind decreases the pressure above the chimney, allowing the "fluid" (aka soot) to rise easier.
- That the shape of an airplane wing is crucial to the entire reason as to why planes can fly (Bernoulli's principle). The fluid traveling over the tear shaped wing travels faster and thus has a lower pressure than the air beneath it, creating lift.
- How a curveball works.

Thermal Expansion
- That if I ever have something stuck in a metal object with a hole in it, I can heat it up and hopefully remove the stuck object.

Heat Transfer
- Why double paned windows keep a house warmer/cooler—thermal conductivity of air is less than glass.
- That an electric burner glows red because of the "blackbody radiation" emitted by all hot objects.

Oscillations
- How grandfathers clocks work/what the thing at the bottom is for.

Sound
- That sound waves aren't really a separate physical entity, but are caused by the impact of neighboring molecules, and that there is no sound in a vacuum.
- That when my wife yells at me I can jump into a box with her and have a giant vacuum suck the air out and I will not hear her!!!!
- Why my guitar strings change tune when I tighten the tension, and why I can get the strings to play "harmonics" by shortening the wavelength.