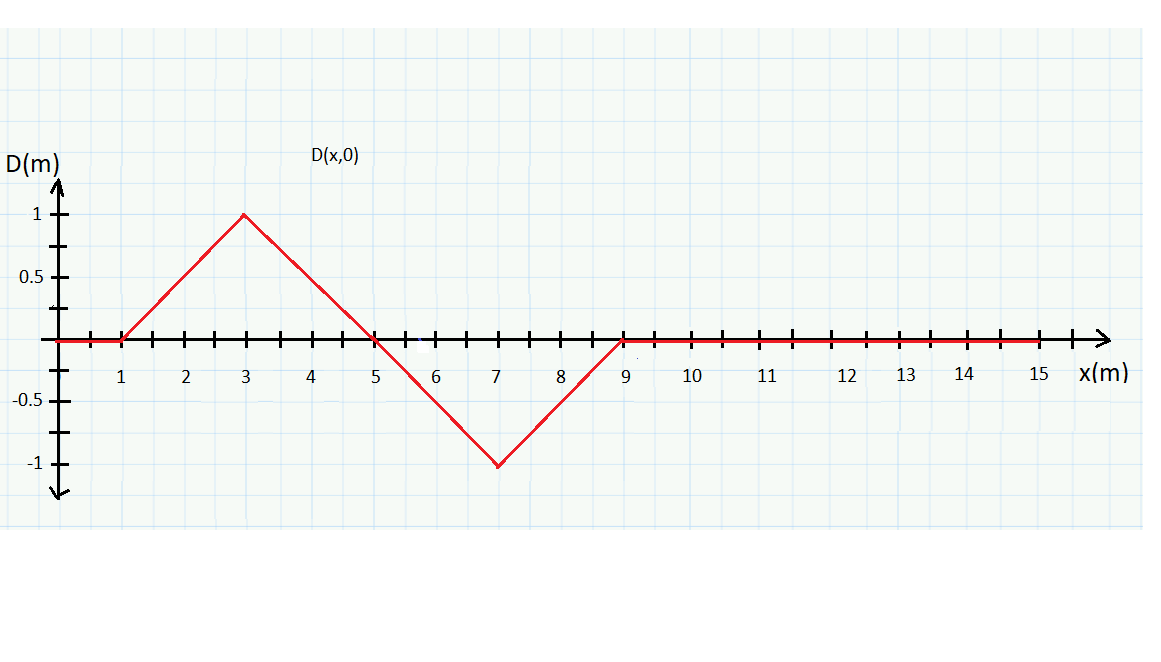
**Assignment 2 Due 2/5**

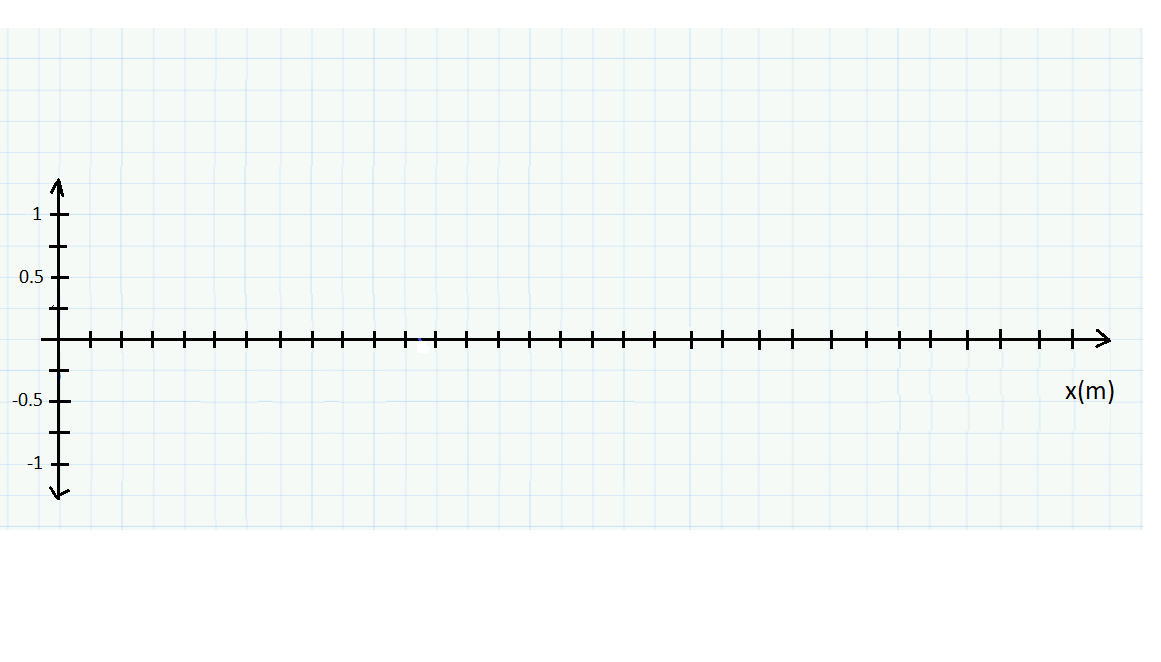
**Problem 1.** As part of your job as a the most brilliant physicist ever, you derive the following equation for how waves propagate through a certain novel material, where α = 32N, and β = 2kg/m.

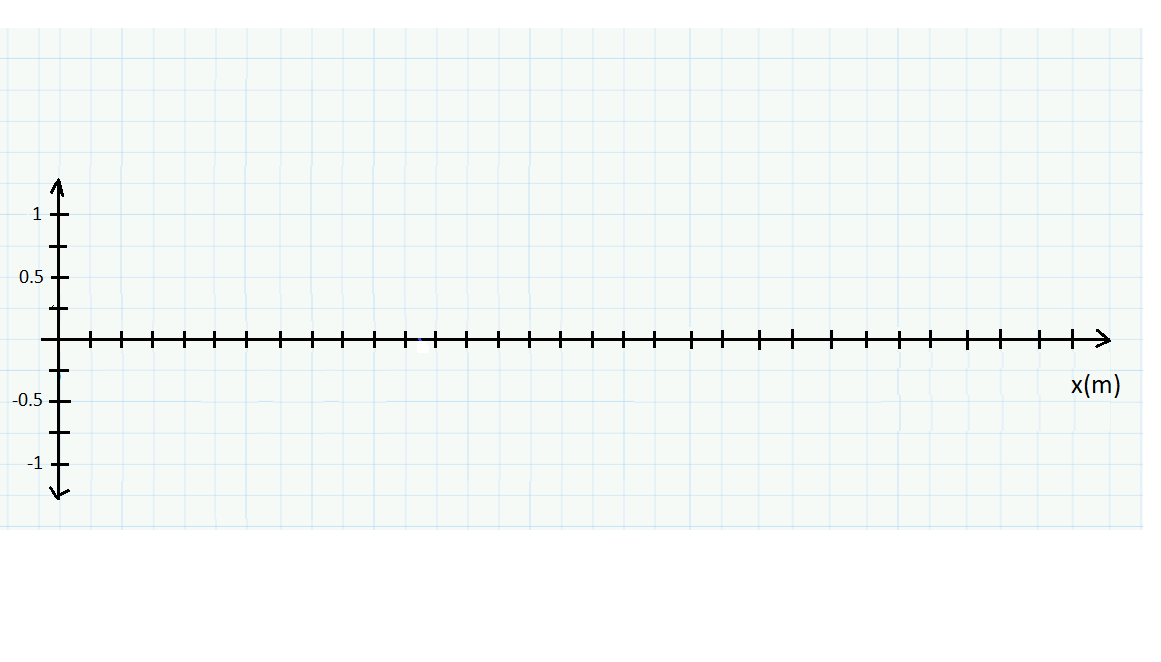


(a) With what velocity will a wave propagate through this material?

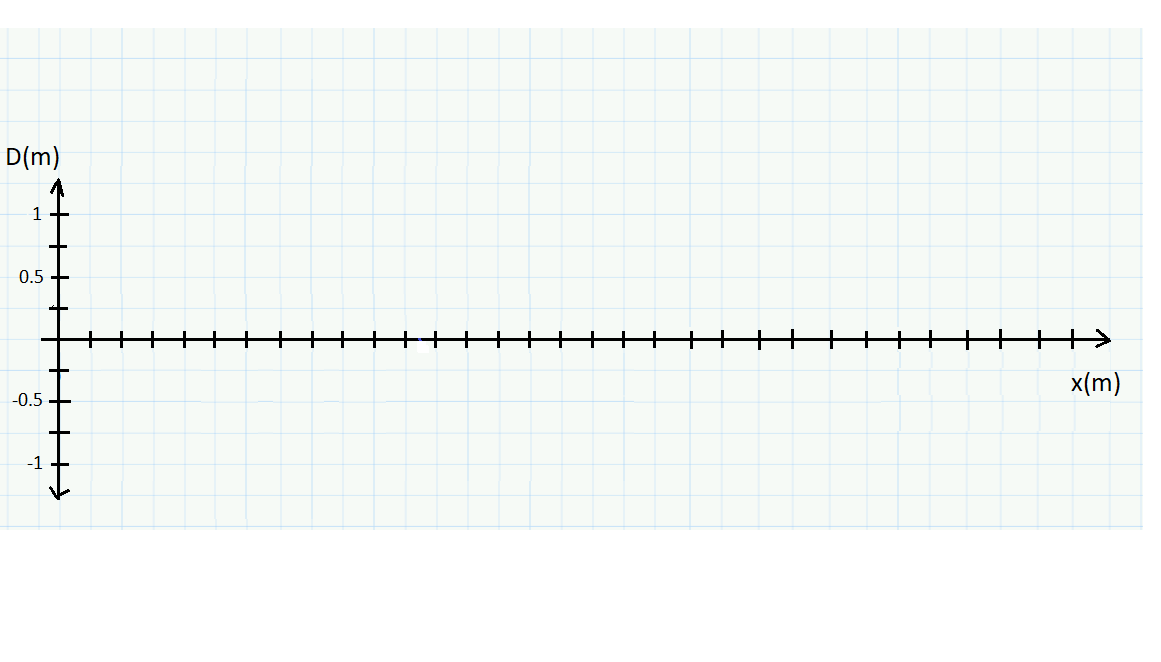
(b) Suppose the particles in the medium were all initially at integer positions, but then are displaced according to the following graph D(x,0). Draw the actual position of the particles if this is a transverse wave. And then if it’s a longitudinal wave.

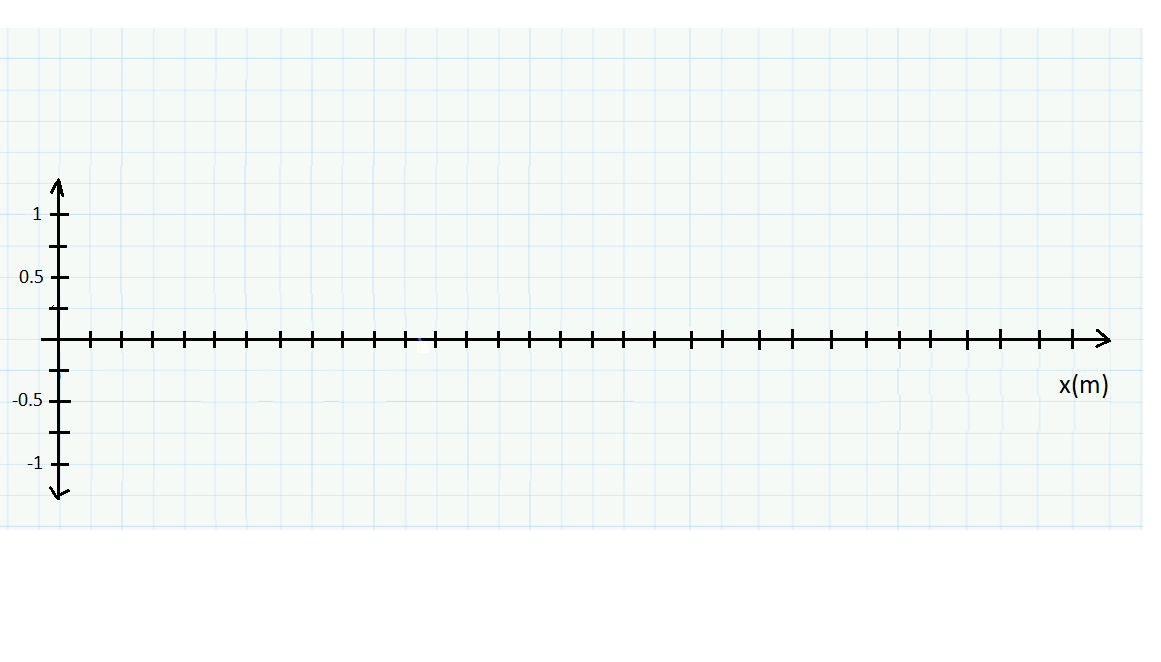


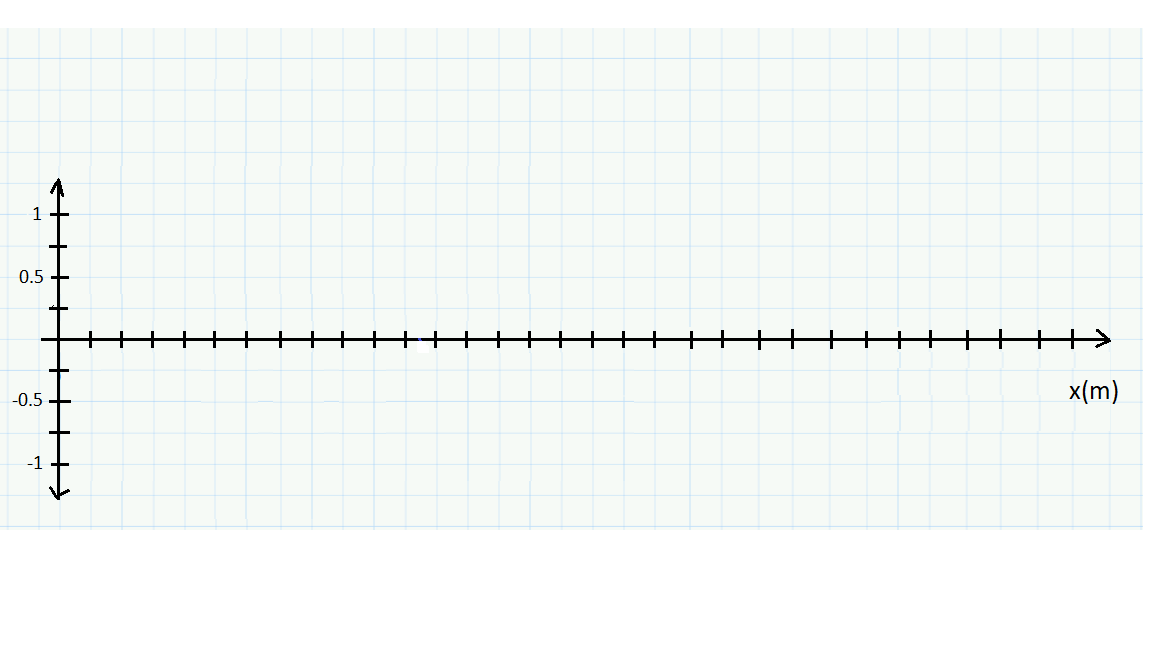




(c) What will D(x,1) look like? And draw the particles’ positions at t = 1, for both the transverse and longitudinal cases in the bottom two graphs:

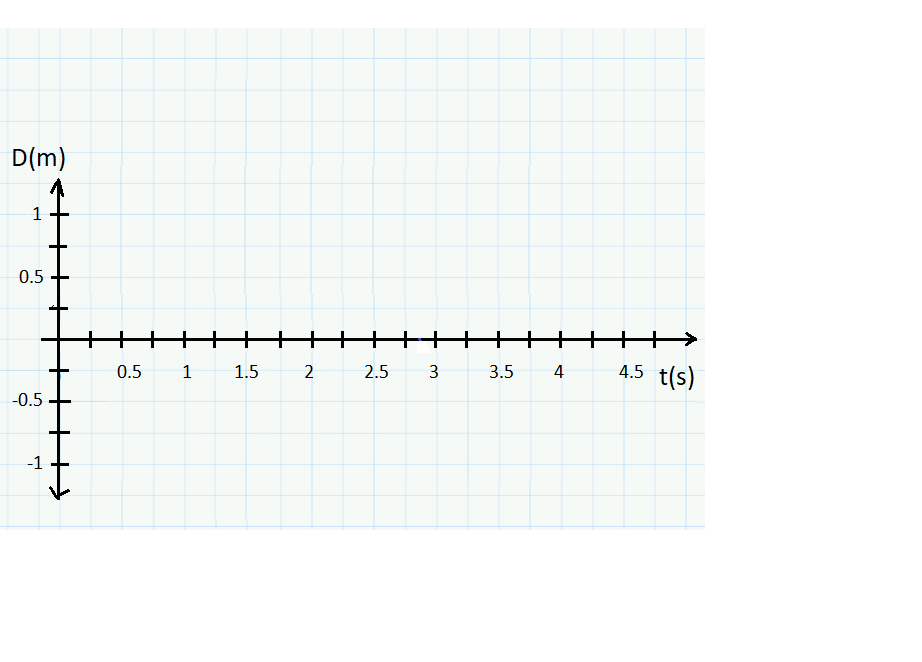






(d) What is the displacement and velocity of the x = 10m particle at time t = 1s? What direction is it moving in (for transverse and longitudinal cases)

(e) Draw a history graph of the point x = 13m, i.e. D(13,t). Between what times is it moving down (transverse) left (longitudinal)? Between what times is it moving up (transverse) right (longitudinal)?

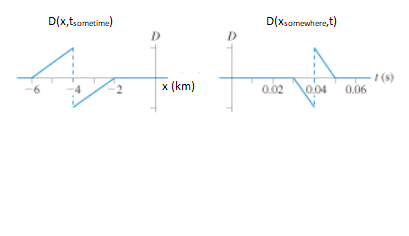


**Problem 2.** Suppose a wave is traveling through a string at velocity v = -20m/s, and that the initial displacement function is , measured in m.

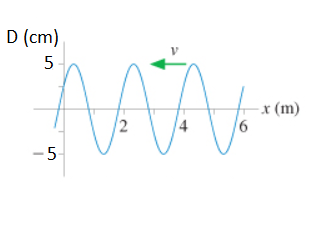
(a) What is D(x,t)? and what is a general expression for the velocity of any point at any time?

(b) What is the displacement and velocity of the point x = -38m at t = 2s? What direction is the direction of its displacement in the transverse/longitudinal cases? What is the direction of its velocity in the transverse/longitudinal cases?

**Problem 3.** When Alderaan exploded, it sent a disturbance through the force. After Obi-Wan Kenobi felt it, it just kept going out into space, eventually making its way to Earth. Physicists here have recently developed a force-sensitive seismograph and it captured the following pictures of the disturbance, plotted below in the form of graphs D(x,tsometime), and D(xsomewhere,t), where xsomewhere and tsometime are definite points in space, time but otherwise unspecified. With what speed and in what direction is the force wave propagating?



**Problem 4.** A mountain climber (m = 70kg) is hanging from a rope. The rope has a mass m = 2kg, and length 20m. When he loses his footing, he inadvertantly shakes the rope, setting up a sinusoidal wave in the rope, depicted below (origin of axis is at the point where rope is anchored, whereas climber is at coordinate x = 20m). At some arbitrary time we will call t = 0, the rope looks like this:



(a) Write down the equation for D(x,0).

(b) Write down the equation for D(x,t).

(c) What is the frequency of oscillation of the string?

(b) What is the maximum displacement of a point on the string?

(c) What is the maximum speed of a point on the string?

(d) What is the maximum acceleration of a point on the string?

(e) If an ant (m = 2mg) on the rope can exert a maximum gripping force of 0.1mN, will it be able to stay on the rope?

(f) Calculate the linear energy density along the length of this rope.

(g) What is the energy in one of its wavelengths?

(h) What is the intensity of the wave along the rope?

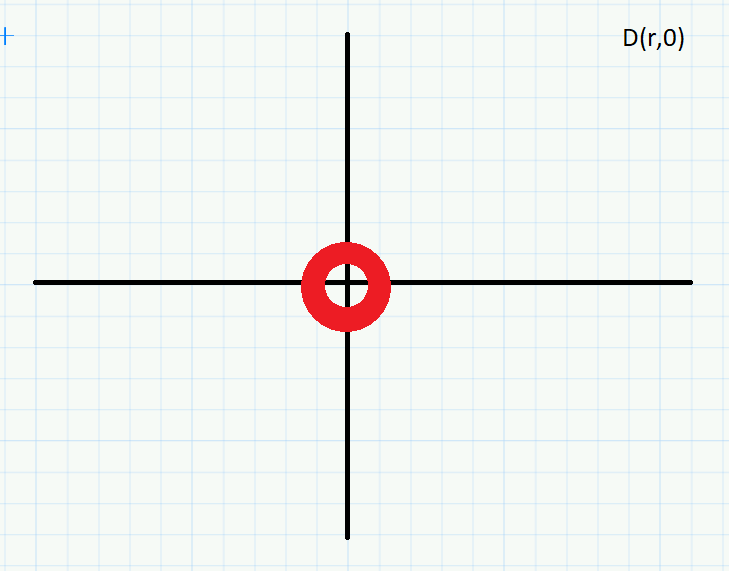
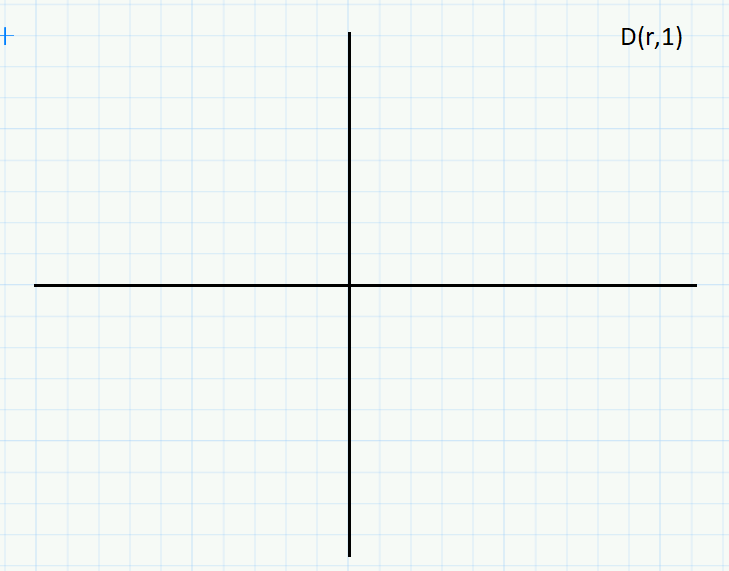
(i) What is the rate at which energy is being delivered to the anchor bolt? This could be a consideration vis a vis whether it comes lose. Just sayin.

**Problem 5.** You’re fed up with school and have decided to make an attempt on the SLO-to-Japan single person kayak speed record. You’re taking a break from rowing one fine afternoon and notice waves passing by. Your kayak is bobing up and down 20 times per minute. A rubber ducky you have tied to your kayak (for good luck) bobs up and down with the waves, and a gps sensor records its maximum speed as 0.70m/s. Finally, you notice that it takes a given wave crest about 1s to pass your 5m long kayak. Using the rubber duck as the origin of your coordinate system, and starting time from when it is at its nadir, write an equation for D(x,t) = Asin(kx-ωt+φ0), assuming the waves are sinusoidal of course, and that the velocity of the wave is ‘positive’.

**Problem 6**. A bomb explodes in a foam-like substance being examined for its protective properties. Its density is ρ = 0.2kg/m3, and its bulk modulus is B = 10N/m. Suppose at time t = 0, the displacement of the foam’s constituent particles is described by



In other words, D = 1cm inside the colored region, and 0 everywhere else.

(a) What is the wave pulse’s velocity?

(b) Depict D(r,1) on the empty graph above. What is its rough amplitude? (only need to know how fast the pulse will travel, and its rough amplitude vs. radius dependence).

**Problem 7.** Consider the same foamy substance, and suppose that the initial 3D pulse is described by the function: , where D is measured in cm.

(a) What is the expression for D(r,t), and v(r,t)?

(b) Consider a point at radius r = 6m. What is its displacement and velocity at t = 1s? Describe the direction of the displacement and velocity if it’s a transverse/longitudinal wave.

**Problem 8.** Now suppose that the aforementioned explosion sets up a sinusoidal wave described by the following equation, where D is measured in cm again: .

(a) What is the wave velocity?

(b) What is the wavelength?

(c) What is the frequency of oscillation?

(a) What is the amplitude of oscillation at the radius r = 10m?

(b) What is the max velocity of the medium at radius r = 10m?

(c) What is max acceleration of the mediumm at radius r = 10m?

(d) What is the energy density of this wave (as a function of r)?

(e) What is the energy in one wavelength of this wave. Note have to integrate over volume: dV = 4πr2dr.

(f) What is the intensity of this wave (as a function of r)?

(g) What is the rate at which energy is passing through the foam?

**Problem 9.** The B-70 Valkrie, a Mach 3 capable bomber, might have been the loudest jet on takeoff (or might not, trying to remember what I read in 6th grade). Suppose that 15km away from the engine, the volume was 60dB.

(a) What is the intensity of the sound wave at this point?

(b) What was the power of the sound waves coming from the engine?

(c) How close to the engine could you get before damage was done to your ears (this is closer than reality, because air viscocity is not accounted for)?

(d) From what maximum distance could you still hear the engine (this is a ridiculously huge number, but in reality, the distance would be far far far far less since energy does get dissipated by the viscocity of the air medium)?