11.1 Traveling waves

11.1.1 : I assume what we're talking about here is y = Asin(wt ± kx), the equation in the data book. This can be used to describe a traveling wave as follows...the amplitude is A (because sine curves range from 1 to -1, multiplying by A will make it range from A to -A). w is defined as 2 x Pi x f and k is defined as $^{2 \times Pi}/_{Lambda}$. The value of t will shift the whole curve to the left or right (assuming + in the middle, increasing t moves it to the left, decreasing to the right). The period of the curve will be defined by the wavelength and frequency in the equation...it's a good idea to play around with this on a graphics calculator (or even better, a prog like the PowerMac graphics calculator, which can let you change parameters and graph in real time)...anyway, it's used for modeling waves.

11.1.2 : This is effectively what I described in the SL bit...In case you forgot

Displacement vs Time ... This graph tracks the movement of a particle as a wave moves through it. With displacement on the vertical axis, and time on the horizontal, the particle will move up and down in a sine curve type pattern. This graph allows up to find both frequency (which will be the number of crests in 1 sec) and period (which will be the time between crests), but tells us nothing about the wave speed or wavelength.

Displacement vs position ... This is basically a 'snapshot' of the displacement of all the particles going through the medium at a given time. Displacement is on the vertical axis, and position (or ie distance from an arbitrary origin in the material) is on the x. The distance between peaks represents the wavelength. The wave speed can not be calculated directly from this graph, but only by combining the information from this and the previous one

11.1.3 : Huygens' principle...This is a geometrical representation of how waves move through media...Each wave front is assumed to be an infinite number of point sources, each radiating in a circle. After a given period of time, a new wave front is drawn along the edges of these radiated circles, and the process is repeated...to draw it on paper, start with a wave front, place a number of points, and from these, draw the waves being emitted as if each of these were a point source. This results in a series of circles, but obstructions can change this...waves could be reflected or absorbed by an object, waves entering a medium of higher optical density will slow down (and so won't go as far). After a given period of time (depends on the speed of the wave), draw an new wave front running along the edges of these circles as appropriate for the situation. The process is repeated over and over until it gets so boring that you stop. This helps to explain some of the phenomena of waves...diffraction...a very thin slit will only have a single point source, and so it will radiate in a circle, or wraps around an object, but you really need to draw a diagram to see that...refraction...as it enters

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the more dense medium, the waves slow down, pulling the wave around, and so on. This model can be applied to any waves but they'll probably be light, water or sound.

11.1.4 : Partial reflection occurs when ever light changes media...when light goes from water to air, some light is reflected from the boundary, ditto going the other way. Total internal reflection occurs when light enters a boundary (from the more dense side) at an angle greater than the critical angle, and all the light is refracted back into the medium. This critical angle can be found by inserting 90 as the angle of refraction in snell's law, thus creating n_1 x sin $i_c = n_2$. Any angle of incidence above this will totally internally reflect. At this exact angle, the light will run along the boundary, and below it, refraction (and partial reflection) will occur as usual.

11.1.5 : Some examples of stuff

Light through optical fibers...This is used both as a communication system, and as a sort of camera in hard to reach places. Light is totally internally reflected through the glass core, which can be bent as long as the light passing through it does not exceed the critical angle (see optics for more info)

Prismatic reflectors...Glass has a critical angle above 45, and so it is possible to use a iss, right angled triangular prism as a reflector...light enters the longest side, bounces off one side, off the other, then out the way it came in...this is more effective than using a mirror because 100% of the light is reflected, where as mirrors are never 100% efficient. This set up can also be rearranged to build a periscope (light goes an and out the two short sides, bouncing off the long one) without mirrors.

Air near hot surfaces...air's refractive index changes with temperature, and so some refraction can occur when waves travel through an area of hot air, making that shimmering type thing you see near the ground on hot days (at least I suppose that's what this means)

11.1.6 : Refractive index is dependent on the wavelength thus different wavelengths of light will be refracted different amounts through the same boundary. Short wavelength light will be refracted more, and long wave length less. This means that if white light is shone onto a prism, then the light can be separated out into it's component colors, red being refracted the least, and violet the most.

11.2 Interference and Diffraction

11.2.1 : This first bit might seem familiar ;)

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If, for example, we have two point sources producing waves in a circle, they will interfere differently at different points...the easiest way to do this is to draw circles out from the source representing the crests (Except now we can call this Huygen's principle)...when two of these coincide, constructive interference produces a bigger crest. When two gaps coincide, we get a bigger trough, when one crest and one trough coincide, there is destructive interference, and they add to zero. This allows the interference pattern, and the amplitude at each point to be found.

Also relevant to the discussion of huygen's principle is that fact that these point sources effectively produce a wave front, since other parts of the wave destruct, thus demonstrating how exactly the Huygen principle can be accounted for (beyond being a geometric representation).

11.2.2 : For two sources to be coherent, they must emit the frequency waves, in the same phase (ie when one emits a crest, so must the other). Path difference is the difference between the distances of a certain point from each source. The the path difference is a multiple of the wavelength, then constructive interference (an antinode) is produced), if it's a multiple + 1/2 complete destructive interference occurs (producing an node), and points in between have something between a node and an antinode. The pattern produced is a series of lines pointing away from the point exactly between the sources, and alternating constructive-destructive-constructive out from the center.

11.2.3 : Light strikes the two slits, and then produces two coherent point sources next to each other. 1) Light striking the center of the screen has an equal path difference from both, and so produces a bright band on the screen level with the slit (since the light is spread over the smallest area). 2) Light traveling out at such an angle that the light from the top source must travel exactly 1/2 a wavelength further than the bottom one to reach the screen. this means they are out of phase, and annul on the screen. As we move further around, the path difference will be 1 wavelength, they will reinforce, and produce a bright band, and so on alternating.

This experiment can be defined by the equation m x wavelength = d sin Ø = xd/D
Where d is the distance between the centers of the two slits, x is the bandwidth (distance between consecutive bright bands on the screen) and D is the distance to the screen)...The xd/D bit assumes a curved screen, but it's ok so long at you're not too far from the center...I don't know if this is really necessary...but seen Optics for more detail.

11.2.4 Thin films...This is straight out of optics, so there might be too much detail...you decide.

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This films...The classic example of this is a thin layer of oil (assumed to have lower refractive index than water) floating on top of water. (This produces a sort of rainbow effect in the right light conditions). When light enters the oil, some of it is reflected (with a phase change). The remaining light continues down and some is reflected of the oil-water boundary (again with a phase change, meaning the two can be ignored...though if the film is like a soap bubble, only one phase change will occur, and it must be accounted for). This means that if the film is a certain thickness, certain wavelengths will be reinforced will others will destructively interfere (this is how they make those sun glasses which look red from the outside etc...). Nb...the light is always assumed to enter and leave vertically, though it will be easier to draw at an angle, this should be noted with any diagram...It may be necessary to think of the angle involved if the question wants fringes on the film rather than certain wavelengths being reinforced/destructively interfering though.

I don't know what to say about newton's rings, since it says no experimental details will be required...well, here's all about it...

Newton's rings...In newton's rings, there is a flat glass surface with a curved plate (think of the bottom part of a sphere being cut off) placed on top of it. This means the gap between the two pieces of glass increases going further out from the center. Light is reflect of the bottom of the curved plate (with no phase change) and off the top of the base plate (with a phase change). This means that to reinforce, the actual difference between the two distance traveled must be (k+1/2) x wavelength (where k is an int). Nb...this means that at the very center there will be a dark spot, not a bright spot (as with the various slit ones above).

11.2.5 : A diffraction grating is basically a series of slits, rather than two (as in young's double slit). These slits produce much more precise lines, because rather than just requiring two beams to coincide, they require many to do so. This produces a much sharper pattern, and is more easy to analyze. If white light goes through the defraction grating, different frequencies will diffract different amounts, and so spectra will be produced. Like this, then, the component colors of light can be found, with there exact wavelengths (because is affects the angle at which the bright bands occur). Calculations can be done with m x wavelength = d sin Ø = xd/D Where d is the distance between the center of two consecutive slits, x is the bandwidth (distance between consecutive bright bands on the screen) and D is the distance to the screen).

Also relevant here is a quick explanation of the diffraction pattern for each single slit (as this 'defines an envelope on the interference patters)...ie it shows what it will be under. There is a large wide peak of intensity in the center, dropping to zero, followed by a series of smaller peaks of half the width of the central one. each minima for this

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is defined by D sin Ø = m x lambda where D is the width of each slit. I don't know if they really want much detail on this...

11.3 Source/detector movement

11.3.1 : Shock waves are generally formed when the source of sound waves is traveling above the speed of sound. as the plane (since it's usually a plane) approaches the speed of sound, the sound waves don't really get away form the plane, but rather build up in front of the plane. Over time, many of these waves constructively interfere, producing what is known as the sound barrier. Once the plane moves faster than this, the sound waves are left behind the plane, creating a shock wave, which follows under the plane. The angle of the shock wave can be found by taking one point to be the source, then finding where the source would have been 1 second ago. from this point, calculate how far the wave would have gone out from this point in that second, and draw in the circle. A line can then be drawn from the point to the edge of the circle (in a tangent). This will be at 90 degrees to a line from the center, and since two sides are known, the angle of the shock wave can be calculated.

11.3.2 : Doppler effect...This effect is seen by the change in frequency of sound when either the source or the observer are moving...this therefore affects the actual number of waves the observer hears per second, and so changes the observed frequency. If the observer and source are moving closer together, then more wavefronts will be observed per second, and so the frequency will be higher. If they are moving apart, then fewer wavefronts will be observed, and so the frequency will be lower.

11.3.3 : When the source is at rest, the distance between wave crests is lambda. The the frequency is f, then the time (T) between crests is $^1/_T$(=f). If we then assume that the source is moving towards the observer at v_s, then in time T, the first crest has moved a distance (d) ... d = vT. In the same time, the source has moved $d_s = v_sT$ in the same direction. At time T, the source emits another wave, and so the distance between these two will be d - d_s ... Therefore, the new wavelength will be d - d_s. This can be expressed as...

lambda` = d - d_s (and since d = lambda , and $d_s = v_sT$)

lambda` = lambda - d_s v_sT

lambda` = lambda - v_s x $^{lambda}/_v$

lambda` = lambda (1 - $^{Vs}/_V$)

The new frequency is given by ...

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f` = $^{V}/_{lambda`}$ = v / (lambda x (1 - $^{Vs}/_{V}$)) , and since $^{V}/_{lambda}$ = f

f` = f / (1 - $^{Vs}/_{V}$) (which is the same as the one in the data book ... if the motion is away from the observer, then Vs will be negative, making the sign in the middle positive, but this can be determined as you work out the problem if you know whether the wavelength should be higher or lower)

When the observer is moving towards the source, the problem is slightly different because the wavelength isn't actually changing, but rather the relative velocity of the waves. The speed of the wave, V` = V + $V_0$. where V is the velocity of sound in air. Thus, f` = $^{V`}/_{lambda}$ = $^{V+V0}/_{lambda}$. Since lambda = $^{v}/_{f}$, we get

f` = (1 + $^{Vo}/_{V}$) f ... This is for an observer moving towards the source, a sign change will be necessary as above).

These can both be applied as appropriate to solve problems.

11.4 Standing waves

11.4.4 : I'll have to look this up...unless anyone else wants to do it.

11.4.2 : An overall graph of a standing wave will look like a sine curve superimposed over a -sine curve. at any given point in time, though, consecutive antinodes will be on opposite sides, so if one is up, the next will be down, then up and so on. The nodes will divide the string into equal segments, and so calculations can be done with a sort of arithmetic sequence thing.

11.4.3 : Equation relating fundamental frequency to tension and mass per unit length.

Edward Heddle tells me that I've confused the symbols for tension and period here, so...
"The formula for the speed of a wave in a string is v = (T/µ)^(1/2), where T is the tension (N) in the string, and the linear density µ = mass/unit length (kg/m). This can be shown with dimensional analysis. This v can be combined with the formula v = fÎ. (N.B. T = 1/f is not the same as tension.) Fiddling around with 2l = Î, gives the fundametnal as f(1) = 1/2l x (T/µ)^(1/2)."

First, I should mention the equation v = square root ($^{T}/_{\mu}$) ... this allows us to calculate the velocity of a wave in a given string based on T, the period and µ, the mass per meter of string. This equation can be equated to v = f x lambda...We can then play around with it, to get various formulae...for example, $^{1}/_{\mu}$ = f^3 x $lambda^2$, and so on...

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11.4.4 : As I've said before, an open end in a pipe will have an antinode, and a closed end will have an node. Therefore, a closed-closed pipe will have a half wavelength, as will an open-open pipe, but an open-closed pipe will have one quarter. These are the fundamental frequencies, then half wavelengths can be added to get the first, then second and so on harmonics. Most of the problems involve relating the length to the wavelength / frequency of the sound produced.

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