Traveling waves

Topics: Traveling waves: why is cos(**k.r**-wt) a plane wave in **k** direction?
Summary: Many students memorize the fact that cos(**k.r**-wt) represents a plane wave in **k** direction without understanding why. This short group activity is designed to help them picture the geometry and "see" why these waves are planes, why they travel in the **k** direction, and why wavelength is inverse with |**k**|.
On the board (or screen) is the question:
"How do we interpret the wave f(x,y,z,t) = cos(**k.r** – w t)"
Allow a brief discussion (some may say plane wave, some may say spherical wave)
With the "grid" handout (I copy onto both sides so they can do it twice if they want)
- Each student picks a **k** = (a, b, 0), where a and b are small positive or negative integers or 0, e.g. (1,0,0) or (0, -2,0) or (1,2,0) They choose their own **k**: but do not choose (0,0,0)! (Tell them that it's easier if they pick **k** purely in x, or purely in y, but if they want a more interesting example to choose both components nonzero. This seems to self-select students w.r.t. the speed at which they complete the activity!
- First draw your **k** on your grid.
- Next, start at the origin and go to each black dot, one at a time, and compute **k . r** at that point, and label the point with the (integer!) value of **k.r**. So e.g. the origin is 0 for everyone, and the next point to the right, which represents **r=(1,0)** will just be the "a" in their **k** vector. Have them label points until they clearly see the "pattern"
- Finally, connect the dots with common values of **k.r**

Now – wrap up with questions to ponder: go back to the "how do you interpret the wave cos(**k.r**-wt). At t=0, look at your grid, what do those lines represent? Picture the physical wave! Why are these called "plane waves", what's "planar" here? *(They are "constant phase" lines, or constant values of the wave. They are the PLANES of constant value if you extend into z-direction)*
- As time goes by, which way do the waves travel?
*(In the **k** direction)*
- If you chose a larger magnitude **k,** what does that do to your picture? (Compare with neighbors who did this and see for yourself!)
(lambda = 2 pi/ |k|, so larger k means the constant phase lines are closer together, smaller wavelength waves)

Written by: Steven Pollock, but this originates from an Oregon state activity: physics.oregonstate.edu/portfolioswiki/doku.php?id=activities:main&file=emplane wave
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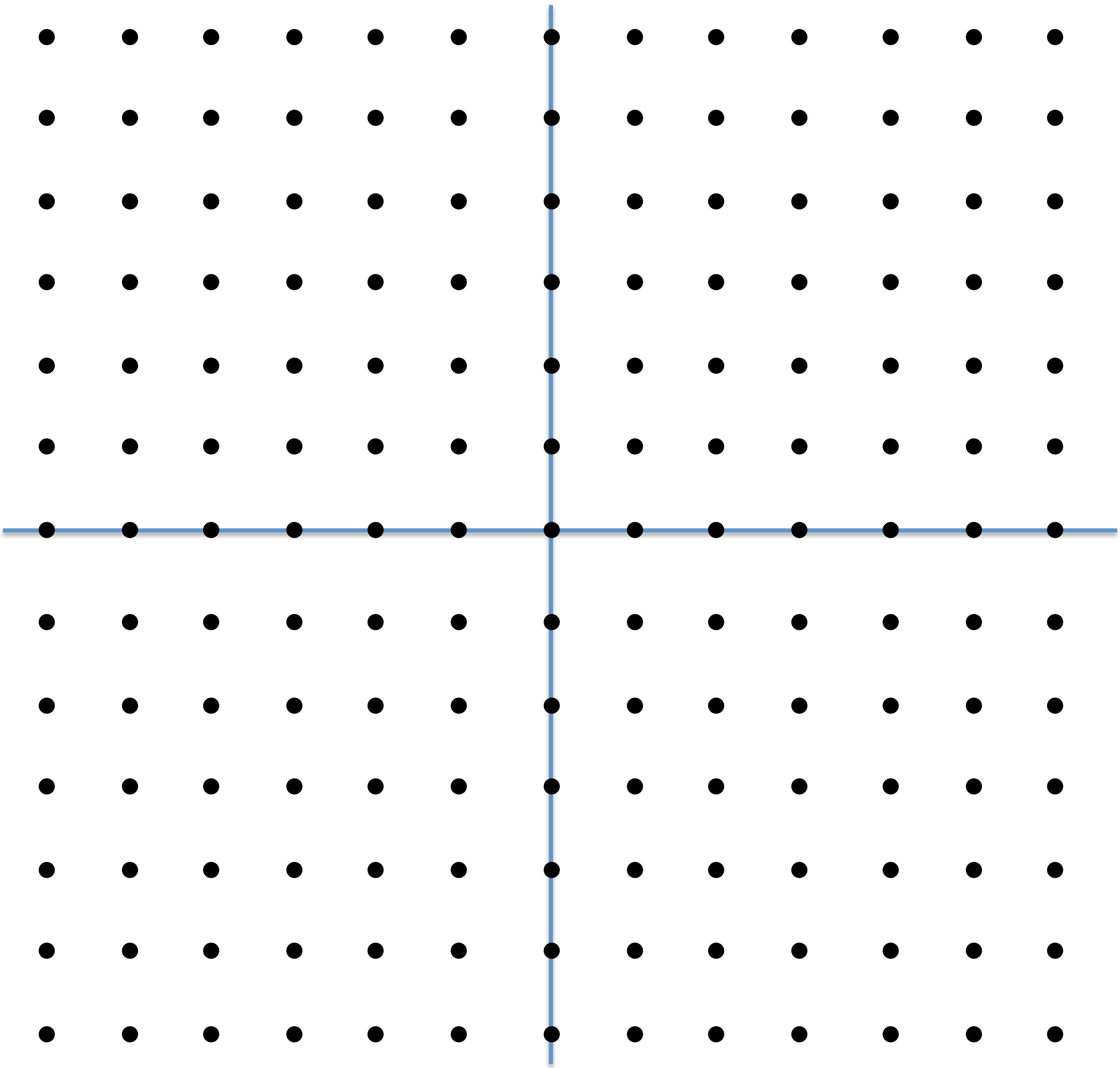
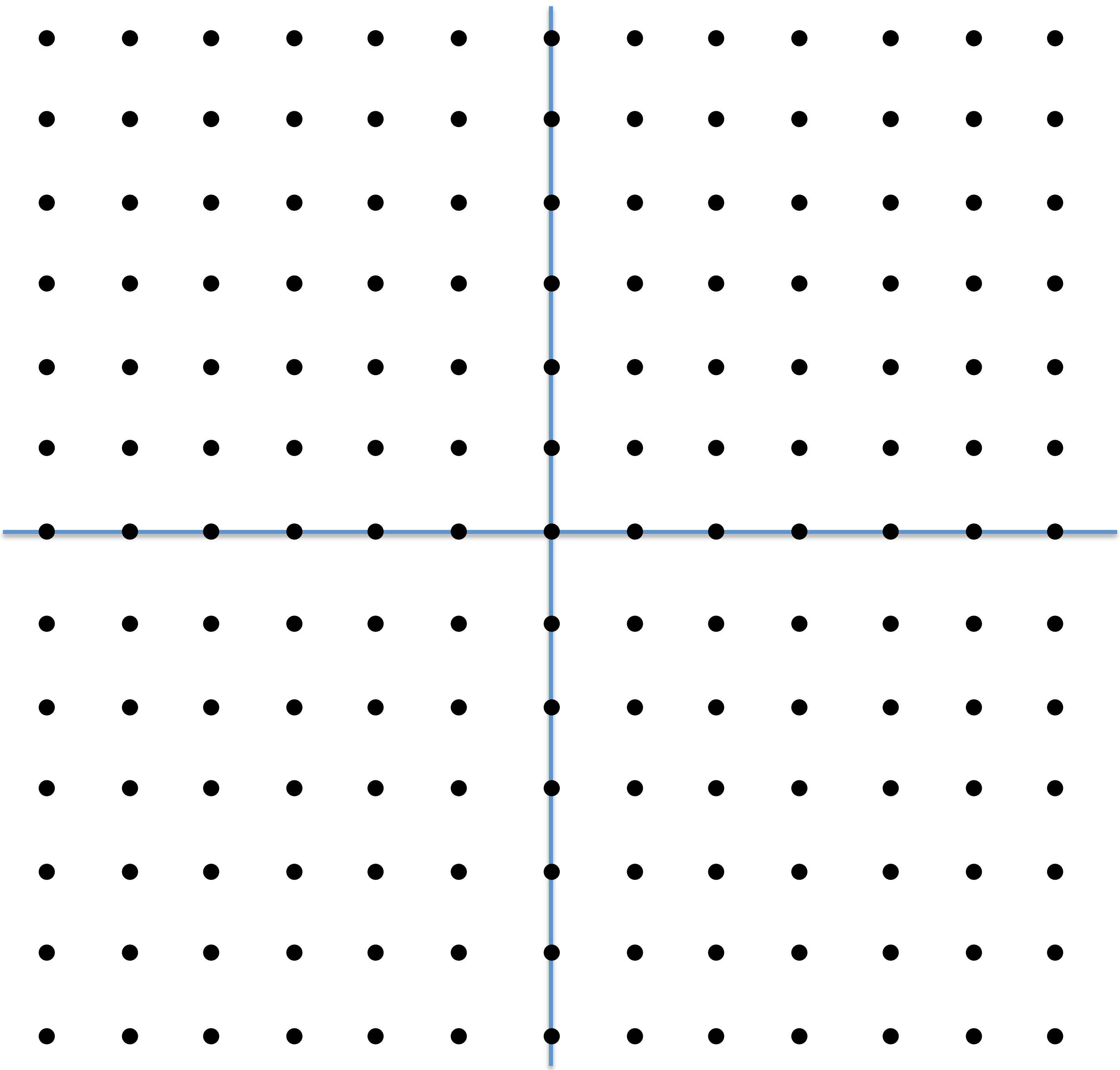
Comments: We took about 5+ minutes for this, it was quick and seemed effective. Some students are just a little confused about the task (labeling dots with value of **k.r**) , so make sure they are all getting started ok.

k . r exercise



k . r exercise



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