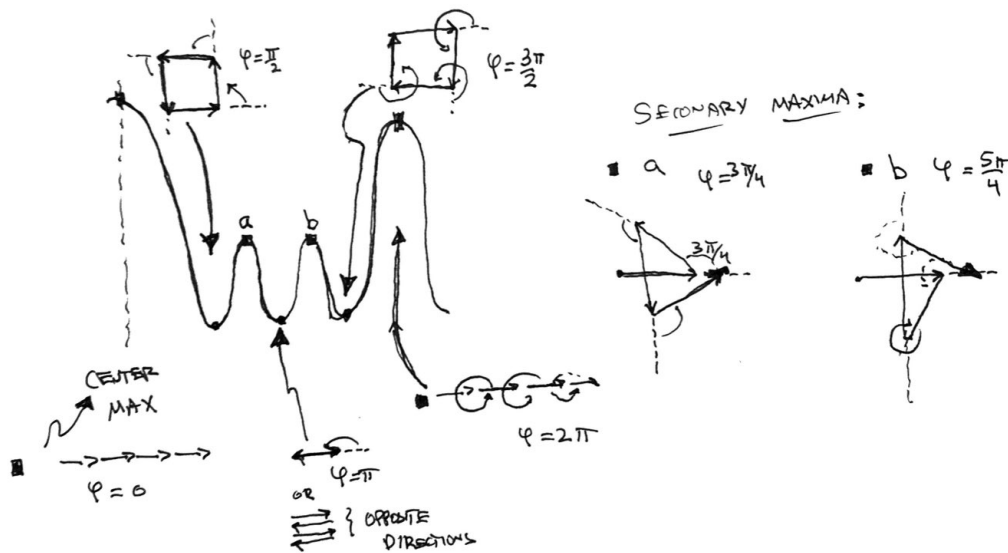


All the questions are worth 1 point.

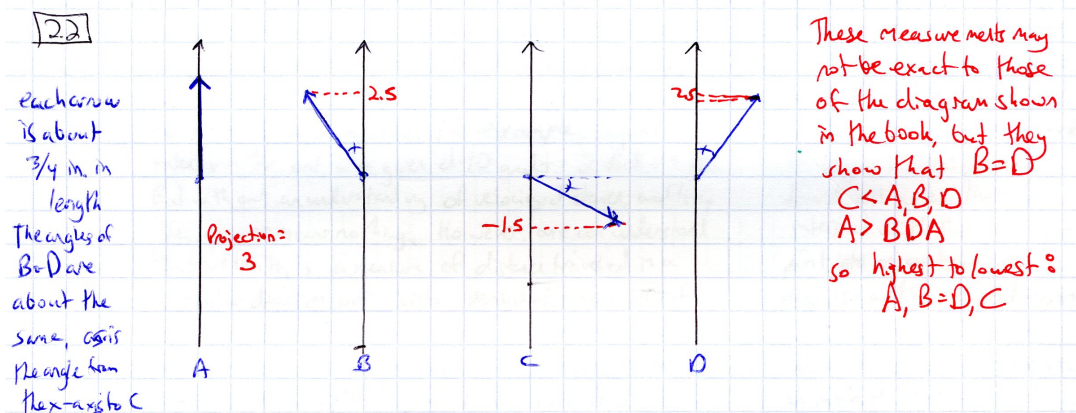
- (1) This sketch covers both parts (a) - the intensity pattern - and (b) the phasor diagrams. The maxima are tagged with filled boxes. The minima are tagged with filled circles. I've just drawn half the intensity pattern, since it is identical on the other side of the central maxima. Although it is not required I have added the relative phase for each diagram.



Key aspects to keep in mind. Every phasor has the same relative angle to the previous phasor. For minima this means the phasor diagrams are regular polygons (although some collapse to a line). This relative angle increases as one moves away from the central maximum. This allows us to determine the phasors for the secondary maxima. These are displayed as "a" and "b" on the right.

- (2) 2.1 The vertical needle has a large negative projection. Since the force is proportional to this projection, this needle will enjoy a relatively large downward force. The needle that points downward to the left has a projection that is smaller in magnitude, but is still negative. So the force on the second needle will be downwards but less strong than that of the vertical needle.

- (3) 2.2 By inspection of the figures the projections in the figures are related as $A > B = D > C$. As Julia M in the 2010 class wrote,



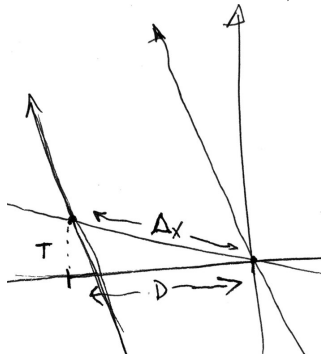
- (4) 2.3 This is a 45-45-90 triangle so the projection on the earth's axis is $3950/\sqrt{2} = 2800$ mi.
- (5) 2.4 Drawing the perpendicular and measuring using a ruler I obtain $-3/8$ " or -0.375 "
- (6) 2.5 Given any arrow a perpendicular axis gives a projection of zero. In three dimensions there are an infinite number of such axes - any axis in the plane perpendicular to the arrow.
- (7) 3.1 With the friction scheme, all the atoms in the analyzer would quickly have the same projection and thus would experience a large upwards force. So the whole beam would be deflected upwards. There would be only one blob on the plate.
- (8) 3.2 There are two sets of data in the plot. The data set with no magnetic field has some width to the peak. So the incoming beam has some width due to the finite width of the slits. When the magnetic field is turned on this width should be increased since the different parts of the beam would experience slightly different magnetic fields. This is what we see; each peak in the data with magnetic field has slightly larger width than the data without the magnetic field. (I would say that "only" is a bit strong here. To check this I would want to see some further calculations and, ideally, additional data.)
- (9) (Optional worth .5 pt)
- (10) (Optional worth 1 pt) Lorentz transformations
- (a) For two events that occur at the same time, $\Delta t' = 0$, and from the second relation we have $\Delta x = \gamma \Delta x'$. The contracted length $\Delta x'$ in the moving frame needs stretching to obtain the length Δx .
- (b) The slip in simultaneity is in the first relation. For events simultaneous in the prime frame, $\Delta t' = 0$, there is still a non-vanishing difference in time in the other frame,

$$\Delta t = \gamma \frac{v \Delta x'}{c^2}$$

Although this is not the slip in simultaneity as we usually express it,

$$T = \frac{v D'}{c^2},$$

it is the same time delay once we realize that $\Delta x'$ is in the frame in which the events are simultaneous. From our work earlier D , is the distance between these events in the frame in which the events are not simultaneous. For instance, like this



In the moving frame $\Delta x'$ is contracted so $D = \gamma \Delta x'$. Thus, the two equations are equivalent.