Problem 1. (5 points) A wave can be represented in many forms

\[ f(z, t) = A_1 \cos(kz - \omega t) + A_2 \sin(kz - \omega t), \]  
\[ = A \cos(kz - \omega t + \delta), \]  
\[ = \text{Re}[\tilde{A}e^{i(kz-\omega t)}]. \]

A wave has two degrees of freedom. In form (1) the freedom is in the choice of \( A_1 \) and \( A_2 \). In form (2) it is in \( A \) and \( \delta \). In form (3) it is in the real and imaginary parts of \( \tilde{A} \). All of these are related as you will now show.

(i) Write \( A_1 \) and \( A_2 \) in terms of \( A \) and \( \delta \).

(ii) Write the real and imaginary parts of \( \tilde{A} \) in terms of \( A_1 \) and \( A_2 \).

Problem 2. (5 points) Another way of writing the real wave in terms of complex exponentials is

\[ f(z, t) = \tilde{A}e^{i(kz-\omega t)} + \tilde{B}e^{-i(kz-\omega t)}. \]

For \( f(z, t) \) to be real, what is the relationship between \( \tilde{A} \) and \( \tilde{B} \)? [Note: As we saw in the previous problem, there should be two independent quantities in this expression. When we have both \( \tilde{A} \) and \( \tilde{B} \) we have four quantities (the real and imaginary parts of \( \tilde{A} \) and \( \tilde{B} \)), thus there must be a relationship between them to reduce the total number of independent quantities to two!]

Problem 3. (10 points) The intensity of sunlight hitting the surface of the Earth is approximately 1300 W/m².

(i) \textit{Estimate} the pressure exerted on a perfect absorber on the surface of the Earth due to sunlight. [Note: We are doing an estimate here so it is not necessary to be extremely precise. For such problems step away from your calculator! We do not need such contrivances to get a good numerical estimate.]

(ii) Is this pressure large or small? For dimensionful quantities we cannot just look at the magnitude of the result, we must compare it to something else. A natural scale to compare to here is the pressure of the atmosphere. Convert your answer from the previous part to atmospheres. [Note: Again since we are doing an estimate we can estimate this conversion also by using \( 10^5 \text{ Pa} \approx 1 \text{ atm.} \)]

(iii) You \textit{knew} that the answer had to be small! That is, you knew that the pressure from sunlight had to be much smaller than the pressure of the atmosphere. Describe a simple concept for a way to verify this is true experimentally. In other words, suppose the pressure from sunlight were a significant fraction of the pressure of the atmosphere, experimentally how could you easily test this?

Problem 4. (10 points) Griffiths Problem 9.11.

\text{Comment:} The point of this problem is that it is a simplified mechanical model of how pressure can be produced from the interaction of electromagnetic fields with a charge. Such models/calculations are useful to help understand the physics. We should be careful to not interpret them too literally.


Problem 6. (5 points) Griffiths Problem 9.15.