

Fundamentals of Engineering Physics-2019.

The 2nd Midterm Exam.

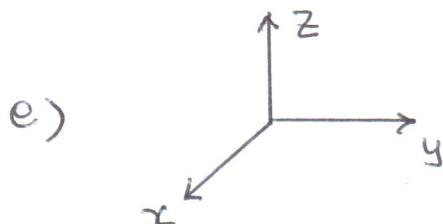
I. Write down the last name of a scientist 10pts. who should get the most credit for the following formulae or coordinates, respectively . (in alphabets only !) .

a) $\vec{B} = \frac{1}{c} \oint \frac{d\vec{l} \times \vec{r} I}{r^2}$

b) $\vec{\nabla} \times \vec{B} = \frac{4\pi}{c} \vec{J}$

c) $\vec{p} = \hbar \vec{k}$ for a massive object .

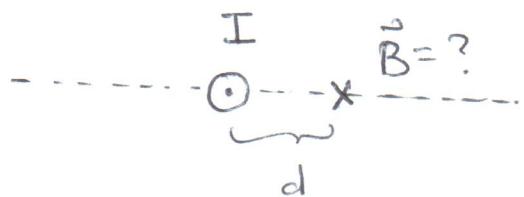
d) $-\frac{\hbar^2}{2m} \nabla^2 \psi(\vec{x}) + V(\vec{x}) \psi(\vec{x}) = E \psi(\vec{x})$



* Some formulae above may turn out to be useful in solving other problems.

II. A wire carrying current "I" runs out of the paper 15pts from infinity to infinity.

- (5) a) Calculate \vec{B} at a point at distance "d" away from the wire and on the paper,



Now, consider an infinite number of wires carrying current " I " in alternating directions as shown above. They are aligned on the same line with an equidistance " d ". There is a gap with a distance " $3d$ " as shown. Calculate \vec{B} at a point marked as "X" (i.e. at a distance " d " away from the nearest wire on the left and a distance " $2d$ " away from the nearest wire on the right), and on the paper.

III, In an empty space with $\rho=0$ and $\vec{J}=0$,
 25pts. Maxwell's equations for time-dependent \vec{E} and \vec{B}
 become .

$$\vec{\nabla} \times \vec{B} = \boxed{a)} \quad (1)$$

$$\vec{\nabla} \cdot \vec{B} = 0 \quad (2)$$

$$\vec{\nabla} \times \vec{E} = \boxed{b)} \quad (3)$$

and

$$\vec{\nabla} \cdot \vec{E} = 0 \quad (4)$$

2 a) Fill in an empty box in (1) with an appropriate expression.

2 b) " (3) "

8 c) From Eqs. (1)-(4), derive an equation for \vec{B}
 (in terms of \vec{B} only) which describes ~~an~~ electromagnetic
 waves.

Here is a particular ~~an~~ electromagnetic field in empty space,

$$E_x = E_0 \cos(\omega t - k_y), \quad E_y = 0, \quad E_z = 0$$

$$B_x = ?, \quad B_y = ?, \quad B_z = ?$$

5 d) Derive the corresponding expressions for B_x, B_y and B_z
 in terms of ω, k and E_0 .

7 e) Derive an expression for the phase velocity of this em wave.
 Write the final expression only in terms of \vec{E}, \vec{B} and c
 (without using $\omega, k, \hat{z}, \hat{x}$ or \hat{y}).

1 f) Because of e), this em wave can be called a
word. wave.

IV. Fill in the empty boxes with word(s) or
25pts. formula(s). Don't fill in derivations!
not necessary here.

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In quantum mechanics, a particle with a definite energy can be described by a a) 1pt wave.

Its frequency " ω ", and wave vector " \vec{k} " are related to particle's energy E and momentum " \vec{p} " via the Bohr frequency condition b) 1pt, and

c) 2pts respectively. Therefore, for a quantum mechanical ptl in the region of constant potential " V " satisfies the dispersion relation

$$\boxed{\text{d) } 5 \text{ pts.}} \quad \boxed{\text{formula}} \quad (1)$$

The corresponding phase velocity is then given by

$$\vec{v}_{\text{ph}}(\vec{k}) \equiv \frac{\text{definition}}{\boxed{\text{e) } 3 \text{ pts.}}} = \frac{\text{formula}}{\boxed{\text{f) } 2 \text{ pts.}}} \quad \boxed{\text{formula}}$$

(Use unambiguous notations for vectors :)
 * Recall that the phase velocity has been derived using the fact that the phase " $\omega t - \vec{k} \cdot \vec{x}$ " is kept constant during propagation.

IV. - cont'd.

A quantum mechanical ptl can be identified as

a g) 2pts. made up of many values of \vec{K}
components
in the context of wave description,

Therefore, the velocity of a quantum mechanical particle which can be derived from the dispersion relation Eq.(1) should be the

h) 2pts.

The expression for this velocity from Eq.(1)
is then given by

$$\boxed{\text{h)}} \stackrel{\substack{\text{def.} \\ \text{use unambiguous vector notation here}}}{=} \boxed{\text{i)}} \stackrel{\substack{\text{3 pts.} \\ \text{formula}}}{=} \boxed{\text{j)}} \stackrel{\substack{\text{2 pts.} \\ \text{formula}}}{=}$$

" $i) = j)$ " exhibits the k) 2pts. words. one of
key concepts of quantum mechanics in a
satisfactory fashion.