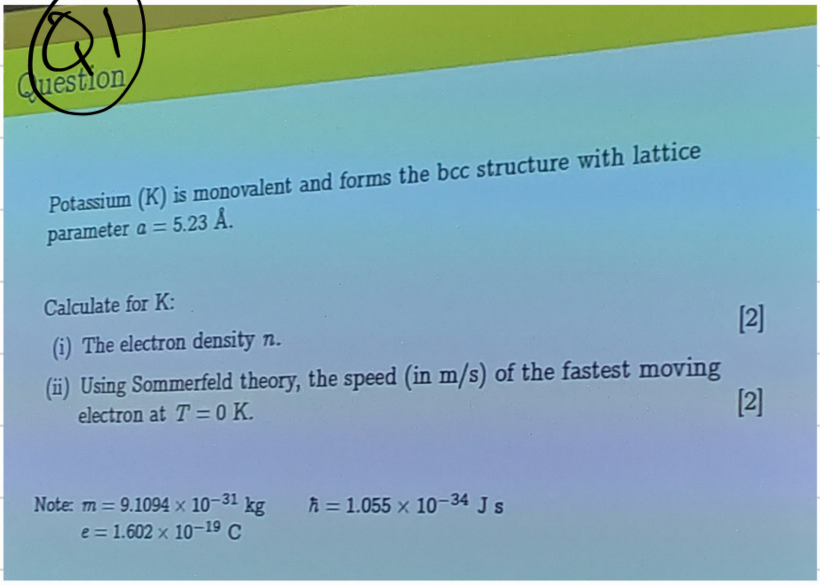
Q1



i) bcc

$a = 5.23$ Å

$$\frac{2.1}{a^3} = 1.4 \times 10^{-2}\ \text{Å}^{-3} = 1.4 \times 10^{22}\ \text{cm}^{-3}$$

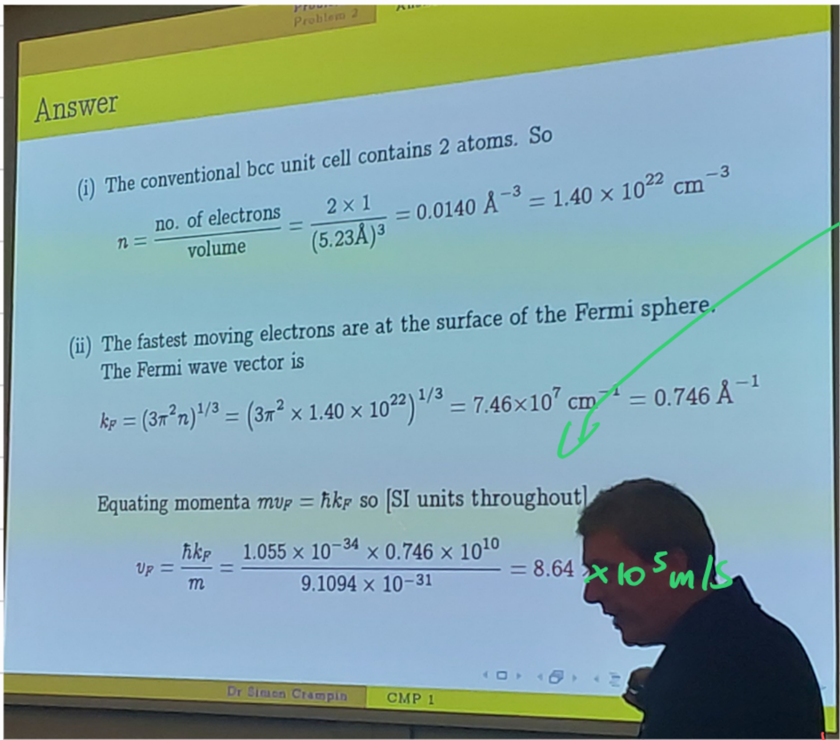
ii) $T = 0$ K

$$k_F = (3\pi^2 n)^{1/3} = 1.6 \times 10^{-7}$$

0.746 Å^{-1}

$$v_F = \frac{\hbar k_F}{m} =$$

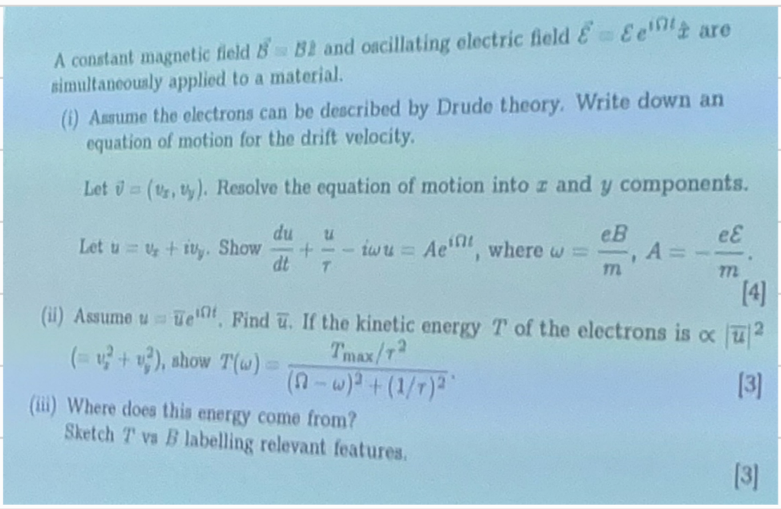
✓ right technique



surface e = largest wavevector

∴ move fastest

Q2



i) Show $\frac{du}{dt} + \frac{u}{\tau} - i\omega u = Ae^{i\Omega t}$

$\omega = eB/m \quad \& \quad A = -e\mathcal{E}/m$

E.O.M.: $\frac{d\vec{p}}{dt} = \vec{F} - \frac{\vec{p}}{\tau} \Rightarrow m\frac{d\vec{v}}{dt}$

$$= -e(\vec{\mathcal{E}} + \vec{v} \times \vec{B}) - \frac{m\vec{v}}{\tau}$$

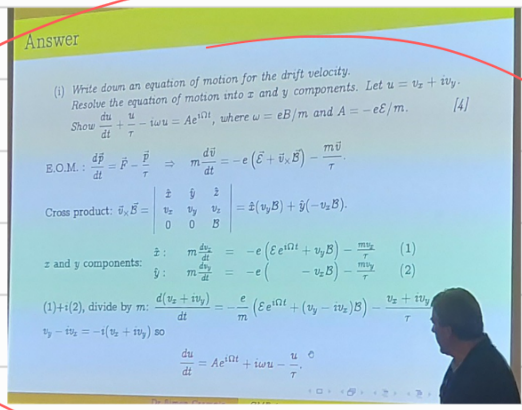
Cross product: $\vec{v} \times \vec{B} = \begin{vmatrix} \vec{x} & \vec{y} & \vec{z} \\ v_x & v_y & v_z \\ 0 & 0 & B \end{vmatrix}$

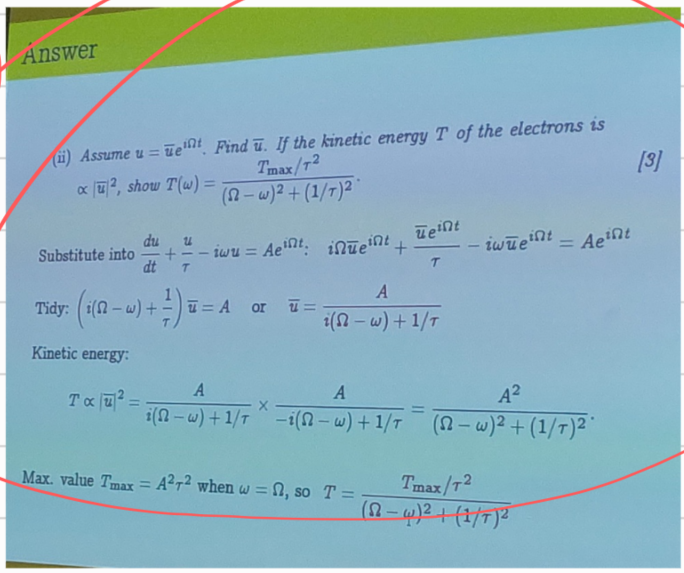
$\hat{x}(v_y B) + \hat{y}(-v_x B)$

ii) $u = \bar{u} e^{i\Omega t}$ ∴ $\bar{u} = \dfrac{u}{e^{i\Omega t}}$

$u = v_x + i v_y$ $\quad \bar{u} = \dfrac{v_x + i v_y}{e^{i\Omega t}}$

$T \propto |\bar{u}|^2$





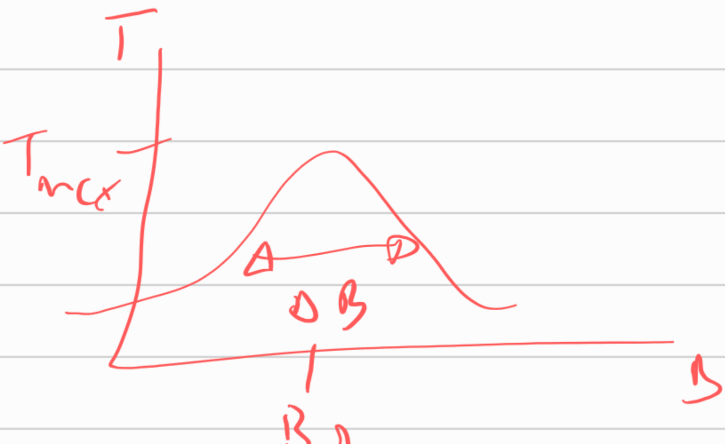
iii) Electric field does not work on e
Energy comes from applied E field

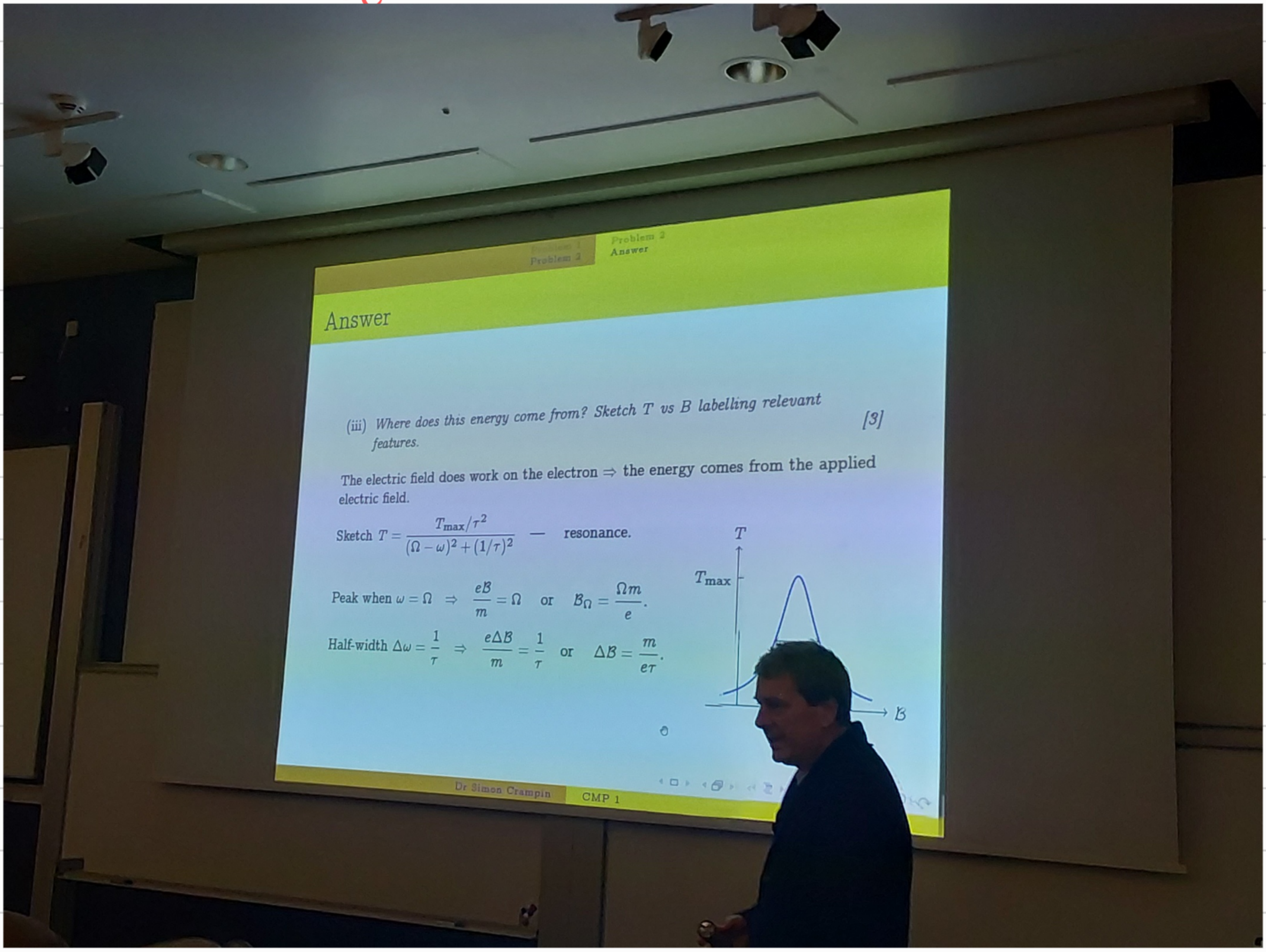
Sketch $T = \dfrac{T_{max}/\tau^2}{(\Omega-\omega)^2 + (1/\tau)^2}$ - resonance

Peak when $\omega = \Omega \Rightarrow \dfrac{eB}{m} = \Omega$ or $B_\Omega = \dfrac{\Omega m}{e}$

Half width $\Delta\omega = \dfrac{1}{\tau} \Rightarrow \dfrac{e\Delta B}{m} = \dfrac{1}{\tau}$ or

$\Delta B = \dfrac{m}{e\tau}$




Problem 2
Answer
Answer
(iii) Where does this energy come from? Sketch T vs B labelling relevant features. [3]
The electric field does work on the electron ⇒ the energy comes from the applied electric field.
Sketch $T = \frac{T_{max}/\tau^2}{(\Omega-\omega)^2+(1/\tau)^2}$ — resonance.
Peak when $\omega = \Omega \Rightarrow \frac{e\mathcal{B}}{m} = \Omega$ or $\mathcal{B}_\Omega = \frac{\Omega m}{e}$.
Half-width $\Delta\omega = \frac{1}{\tau} \Rightarrow \frac{e\Delta\mathcal{B}}{m} = \frac{1}{\tau}$ or $\Delta\mathcal{B} = \frac{m}{e\tau}$.
T
T_{max}
$\mathcal{B}$
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CMP 1