



## ENGINEERING PHYSICS

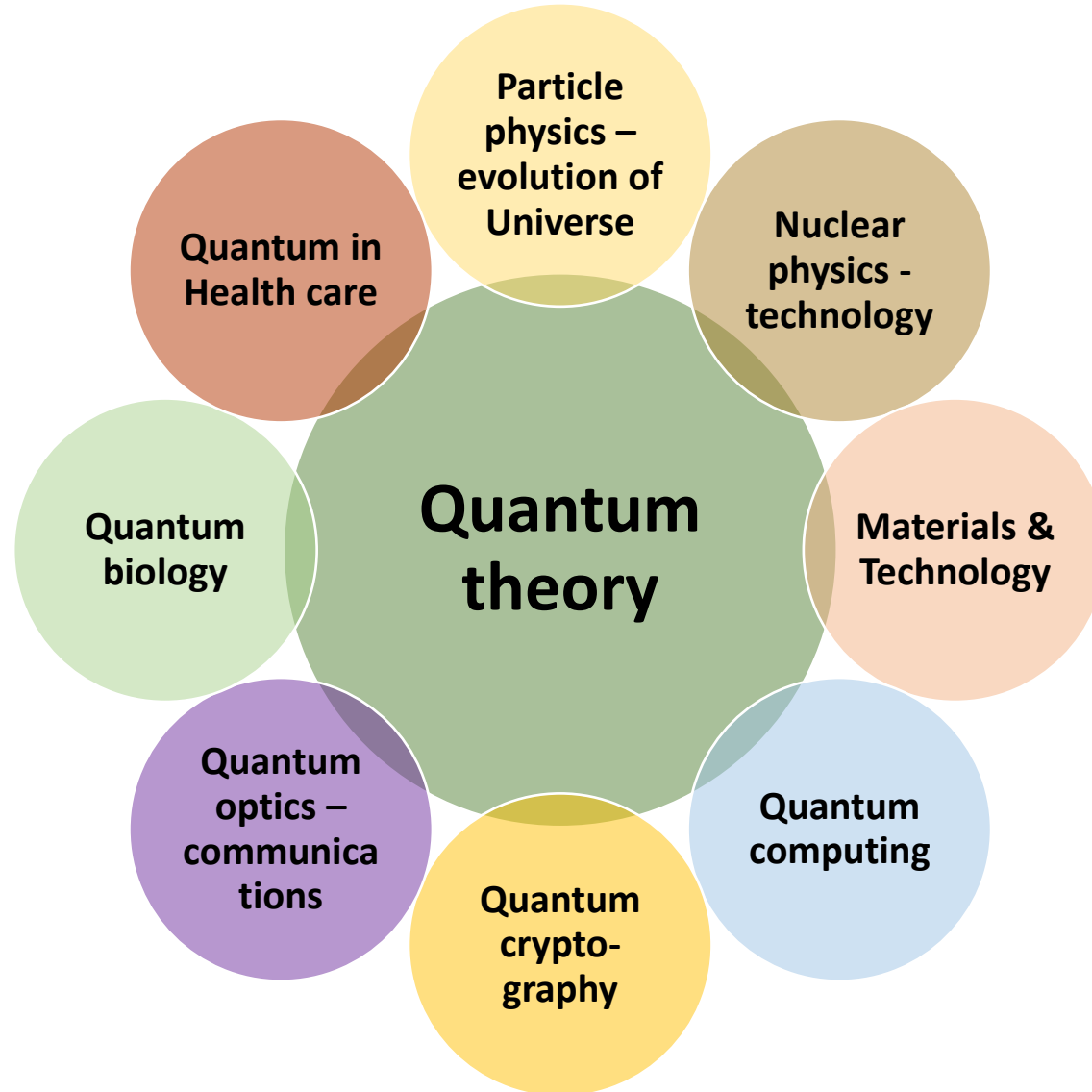
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Department of Science and Humanities

# ENGINEERING PHYSICS

## Quantum theory impacts .....



*The universe is quantum by nature.....*

# ENGINEERING PHYSICS

## Relevance of this course to engineering and technology

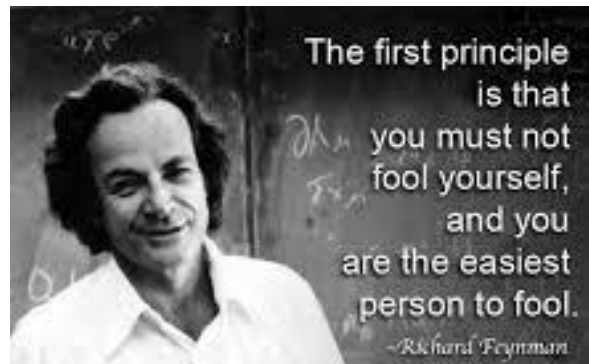
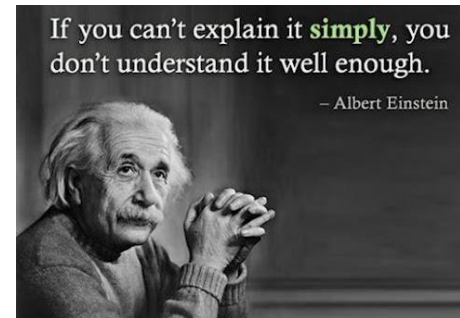
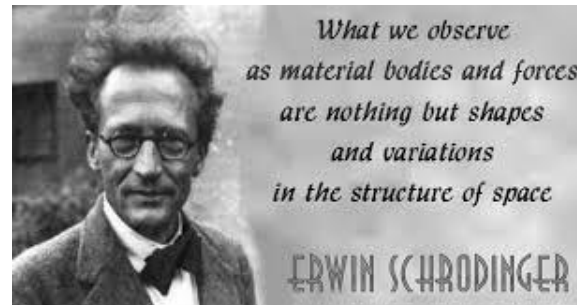
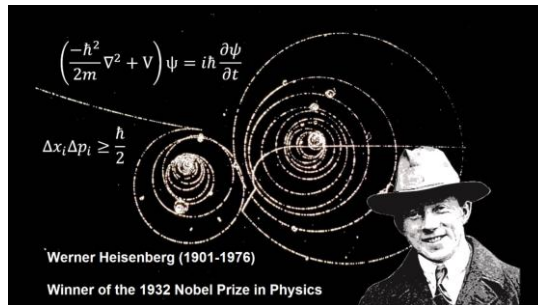
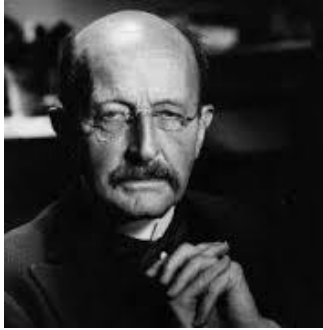
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- **Rapidly evolving technology solutions in small sizes**
  - 3 – 5nm VLSI chips
  - Quantum dot lasers
  - High resolution GPS
  - Medical imaging devices
  - High density storage devices .....
- **Quantum computing**
  - Quantum entanglement
  - QUBITS
  - Quantum computing

# ENGINEERING PHYSICS

## The galaxy of scientists .....

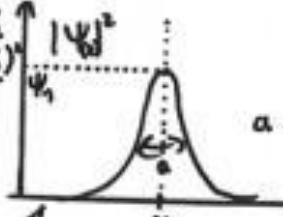
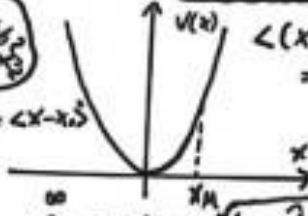


# ENGINEERING PHYSICS

## The simple mathematics.....



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$$\begin{aligned}
 \langle \phi_k | \phi_{k'} \rangle &= \langle \phi_k | \int_{-l/2}^{l/2} dx |x\rangle \langle x| \phi_{k'} \rangle \Rightarrow \left( \frac{2l}{\pi} n + k_0 \right) \frac{l}{2} = \frac{\pi}{2} (2l-1), \quad l=1,2,\dots \Rightarrow k_0 = -\frac{\pi}{2} \quad \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \\
 \langle \phi_k | \phi_{k'} \rangle &= \int_{-l/2}^{l/2} dx \phi_k^*(x) \cdot \phi_{k'}(x) \quad \psi_n(x) = \sqrt{\frac{2}{l}} \cos \left[ \frac{\pi}{2} (2n-1)x \right]; \quad \psi_n(x) = \sqrt{\frac{2}{l}} \sin \left[ \frac{\pi}{2} nx \right] \\
 \langle \phi_k | \phi_{k'} \rangle &= \frac{1}{2} \int_{-l/2}^{l/2} dx e^{-ikx} e^{ik'x} \stackrel{!}{=} 0; \quad k \neq k' \quad \hat{H} \psi_n(x) = -\frac{\hbar^2}{2m} \partial_x^2 \psi_n(x) = \frac{\hbar^2}{2m} \left( \frac{\pi}{2} (2n-1) \right)^2 \psi_n(x) \\
 &\quad E_{ns} = \frac{\hbar^2}{2m} \frac{\pi^2}{l^2} (2n-1)^2, \quad n=1,2,\dots; \quad \hat{H} \psi_{na}(x) = \frac{\hbar^2}{2m} \left( \frac{2\pi}{l} \right)^2 \psi_{na}(x) \\
 |\psi(x)|^2 &= |\psi_0|^2 e^{-\frac{(x-x_0)^2}{2a^2}} \quad \int_{-\infty}^{\infty} dx e^{-\frac{x^2}{2a^2}} = \sqrt{\frac{\pi}{2}} \quad a \approx 10^{-10} \text{ m} \\
 A &= \frac{1}{2a^2} \Rightarrow |\psi_0| = \frac{1}{(2\pi a^2)^{1/4}} \quad \hat{H} \psi_a = -\frac{\hbar^2}{2m} \partial_x^2 \psi_a(x) = \frac{\hbar^2}{2m} \frac{1}{2a^2} \psi_a(x) - \frac{\hbar^2}{2m} \frac{1}{4a^4} (x-x_0)^2 \psi_a(x) \\
 &\quad = -\frac{\hbar^2}{2m} \left( -\frac{1}{2a^2} + \left( \frac{1}{2a^2} (x-x_0) \right) e^{-\frac{(x-x_0)^2}{2a^2}} \right) \psi; \quad V(x) = \frac{\hbar^2}{2m} \frac{1}{4a^4} (x-x_0)^2 \\
 \hat{H} &\rightarrow \hat{H} = -\frac{\hbar^2}{2m} \partial_x^2 + V(x); \quad \hat{H} \psi_a = \frac{\hbar^2}{2m} \frac{1}{2a^2} \psi_a = E_a \psi_a \quad \omega = \frac{\hbar}{2ma} \quad E_a = \frac{\hbar^2}{2m} \frac{1}{2a^2} \\
 V(x) &= \frac{1}{2} m \omega^2 (x-x_0)^2 \rightarrow m \omega^2 = \frac{\hbar^2}{m 4 a^4} \Rightarrow \omega = \frac{\hbar}{2ma} \\
 [\hat{p}, \hat{x}] &= \frac{\hbar}{i}; \quad \hat{p} = \frac{\hbar}{i} \partial_x / \hat{H} = \frac{\hat{p}^2}{2m} + \frac{1}{2} m \omega^2 \hat{x}^2 \\
 1. \quad a^2 + b^2 &= (a+ib)(a-ib); \quad a, b \in \mathbb{R}; \quad 2. \quad (a\hat{p} + ib\hat{x})(a\hat{p} - ib\hat{x}), \quad a, b \in \mathbb{R} \\
 &= a^2 \hat{p}^2 + iba\hat{x}\hat{p} - iab\hat{p}\hat{x} + b^2 \hat{x}^2 = a^2 \hat{p}^2 + b^2 \hat{x}^2 - b a \hbar \\
 \hat{H} &= (a\hat{p} + ib\hat{x})(a\hat{p} - ib\hat{x}) = b a \hbar; \quad a^2 = \frac{1}{2m}; \quad b^2 = \frac{1}{2} m \omega^2 \\
 \text{Def: } C^+ &= \frac{1}{\sqrt{\hbar \omega}} (a\hat{p} + ib\hat{x}); \quad C^- = \frac{1}{\sqrt{\hbar \omega}} (a\hat{p} - ib\hat{x}) \Rightarrow \hat{H} = \hbar \omega C^+ C^- + \frac{1}{2} \hbar \omega \\
 \left( \sqrt{\frac{\hbar}{2m\omega}} \right) |n\rangle &\in \mathbb{C} \quad \{ |n\rangle \}_{n=0}^{\infty} \text{ is } \text{SU}(2) \cong S^3 \quad A \rightarrow \omega \bar{A} \omega^{-1}
 \end{aligned}$$



# ENGINEERING PHYSICS

What you need to know....

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## Prerequisites:

1. C grade in the Physics course at the 11<sup>th</sup> and 12<sup>th</sup> grade
2. A good understanding of EM waves and Modern Physics topics in the 11<sup>th</sup> and 12<sup>th</sup> grade
3. Basics ideas of Mathematics - differential equations and their solutions, concepts of integration, exponential functions, series expansions, fundamental concepts of Probability ( 11<sup>th</sup> and 12<sup>th</sup> grade)

# ENGINEERING PHYSICS

## Course content .....

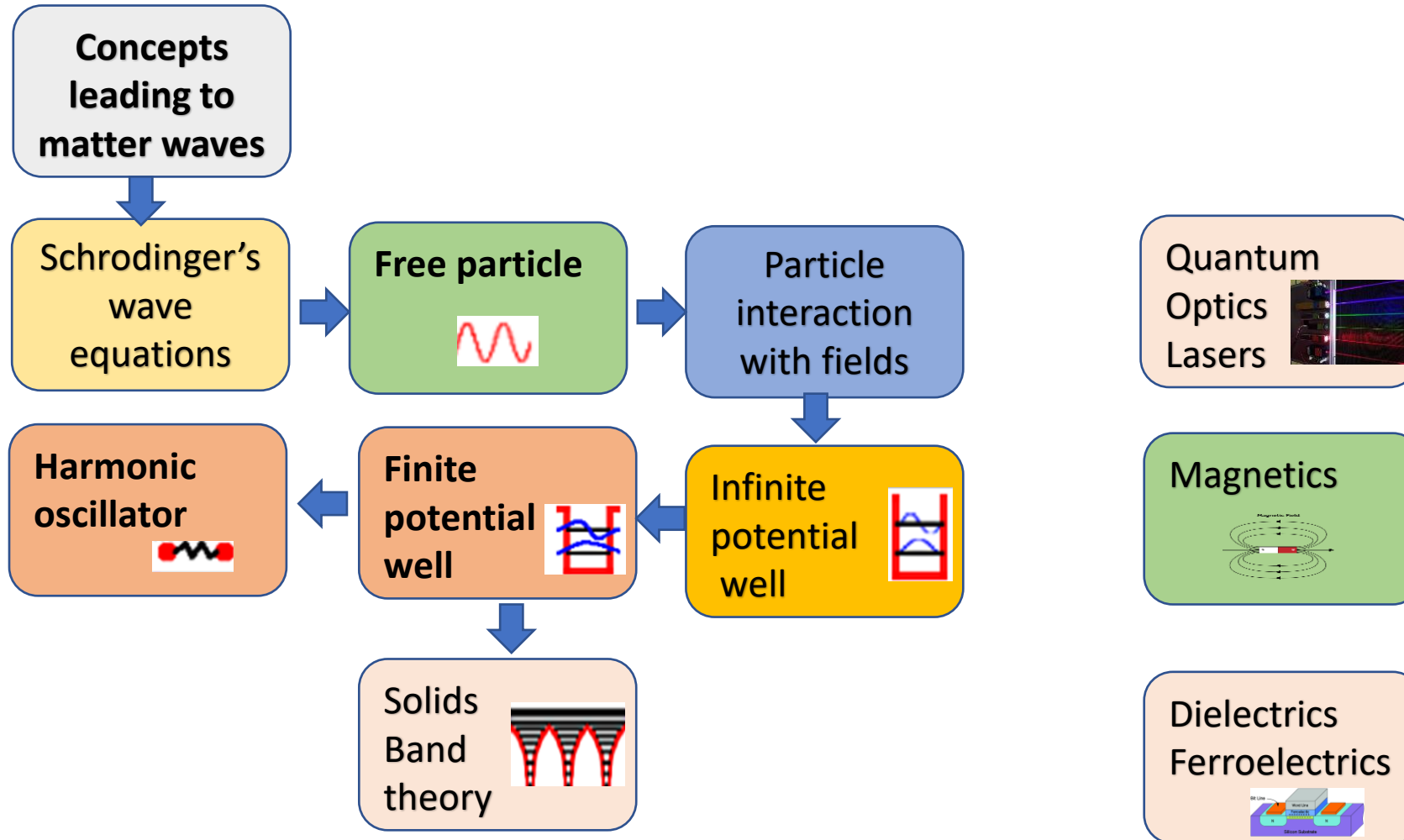
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- Unit I:** Review of concepts leading to Quantum Mechanics
- Unit II:** Quantum Mechanics and Simple Quantum Mechanical Systems
- Unit III:** Application of Quantum Mechanics to electrical transport in Solids
- Unit IV:** Application of Quantum Mechanics to Optical waves
- Unit V:** Quantum mechanical treatment of Magnetics and Dielectrics

# ENGINEERING PHYSICS

The flow .....





➤ ***Suggested Textbook:***

1. ***Concepts of Modern Physics, Arthur Beiser, Chapters 1,2,3,5 and 10***

➤ ***Additional reference:***

1. ***Learning materials prepared by the Department of Physics***
2. ***“Quantum Physics of Atoms Nuclei and Molecules”, Robert Eisberg, Robert Resnick, Wiley, 2006.***
3. ***“Quantum Physics”, S Gasiorowicz, 3rd Edition, Wiley Publications, 2007***
4. ***“Lectures on Physics”, Feynman, Leighton and Sands, Vol. 1-3, 13th Reprint, Narosa Publications, 2012***

# ENGINEERING PHYSICS

## Discussion forum .....

➤ <https://forum.pesu.io/>



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### 🚩 About the Engineering Physics category

This category is for Engineering Physics (UE19PH101) from the S&H department.



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# ENGINEERING PHYSICS

## The grading mechanism .....

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### In Semester Assessment :

#### Quiz:

- Self assessment quiz at the end of every class

#### Assignments at the end of every week with deadlines (10m)

- MCQ's, Numericals, Short answers

#### Internal Assessment tests

- Two Computer based tests end of week #6 and week #12 of 50/60 minutes duration (15m each)

### End Semester Assessments

- Pen and paper examination of 3hrs duration (100m)

**Final Grading = 40%ISA + 60%ESA**



# THANK YOU

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