

CORE PHYSICS THEORIES FOR BEGINNERS

PHYSICS: CORE THEORIES FOR BEGINNERS

CORE PHYSICS THEORIES FOR BEGINNERS OFTEN SEEM DAUNTING, BUT UNDERSTANDING THE FUNDAMENTAL PRINCIPLES THAT GOVERN OUR UNIVERSE CAN BE INCREDIBLY REWARDING AND SURPRISINGLY ACCESSIBLE. THIS COMPREHENSIVE GUIDE AIMS TO DEMYSTIFY SOME OF THE MOST CRUCIAL CONCEPTS IN PHYSICS, BREAKING THEM DOWN INTO DIGESTIBLE EXPLANATIONS FOR ANYONE JUST STARTING THEIR JOURNEY. WE'LL EXPLORE THE BEDROCK OF CLASSICAL MECHANICS, THE MYSTERIOUS WORLD OF THERMODYNAMICS, THE WAVE-PARTICLE DUALITY OF LIGHT AND MATTER, AND THE MIND-BENDING PRINCIPLES OF EINSTEIN'S RELATIVITY. BY GRASPING THESE FOUNDATIONAL THEORIES, YOU'LL BUILD A SOLID FRAMEWORK FOR UNDERSTANDING MORE ADVANCED PHYSICS TOPICS AND APPRECIATE THE INTRICATE WORKINGS OF EVERYTHING AROUND US, FROM THE SMALLEST ATOM TO THE LARGEST GALAXY.

TABLE OF CONTENTS

INTRODUCTION TO CORE PHYSICS THEORIES
CLASSICAL MECHANICS: THE FOUNDATION OF MOTION
NEWTON'S LAWS OF MOTION
ENERGY, WORK, AND POWER
THERMODYNAMICS: THE SCIENCE OF HEAT AND ENERGY
THE LAWS OF THERMODYNAMICS
ENTROPY AND THE ARROW OF TIME
ELECTROMAGNETISM: THE FORCE UNIFYING ELECTRICITY AND MAGNETISM
ELECTRIC FIELDS AND CHARGES
MAGNETIC FIELDS AND THEIR INTERACTIONS
QUANTUM MECHANICS: THE PHYSICS OF THE VERY SMALL
WAVE-PARTICLE DUALITY
QUANTUM SUPERPOSITION AND ENTANGLEMENT
RELATIVITY: SPACE, TIME, AND GRAVITY REDEFINED
SPECIAL RELATIVITY
GENERAL RELATIVITY
CONCLUSION

CLASSICAL MECHANICS: THE FOUNDATION OF MOTION

CLASSICAL MECHANICS IS, IN MANY WAYS, WHERE MOST PHYSICS JOURNEYS BEGIN. IT'S THE STUDY OF HOW OBJECTS MOVE AND INTERACT UNDER THE INFLUENCE OF FORCES, AND IT'S BEEN INCREDIBLY SUCCESSFUL IN DESCRIBING EVERYTHING FROM A THROWN BASEBALL TO THE ORBITS OF PLANETS. THINK OF IT AS THE RULEBOOK FOR THE EVERYDAY WORLD WE EXPERIENCE.

NEWTON'S LAWS OF MOTION

SIR ISAAC NEWTON'S THREE LAWS OF MOTION ARE THE CORNERSTONES OF CLASSICAL MECHANICS. THEY EXPLAIN THE RELATIONSHIP BETWEEN AN OBJECT AND THE FORCES ACTING UPON IT, AND THE MOTION THAT RESULTS.

- **NEWTON'S FIRST LAW (LAW OF INERTIA):** AN OBJECT AT REST STAYS AT REST, AND AN OBJECT IN MOTION STAYS IN MOTION WITH THE SAME SPEED AND IN THE SAME DIRECTION UNLESS ACTED UPON BY AN UNBALANCED FORCE. ESSENTIALLY, OBJECTS LIKE TO KEEP DOING WHAT THEY'RE ALREADY DOING. IF A BOOK IS SITTING ON A TABLE, IT WILL STAY THERE FOREVER UNLESS YOU PUSH IT. SIMILARLY, IF A HOCKEY PUCK IS GLIDING ACROSS FRICTIONLESS ICE, IT WILL KEEP GLIDING AT A CONSTANT SPEED INDEFINITELY.
- **NEWTON'S SECOND LAW (FORCE AND ACCELERATION):** THE ACCELERATION OF AN OBJECT IS DIRECTLY PROPORTIONAL TO THE NET FORCE ACTING ON IT AND INVERSELY PROPORTIONAL TO ITS MASS. THIS IS OFTEN EXPRESSED AS THE

FAMOUS EQUATION $F = ma$, WHERE F IS THE FORCE, m IS THE MASS, AND a IS THE ACCELERATION. THIS LAW TELLS US THAT IF YOU PUSH HARDER ON AN OBJECT (INCREASE F), IT WILL ACCELERATE MORE. IF THE OBJECT IS HEAVIER (INCREASE m), IT WILL ACCELERATE LESS FOR THE SAME PUSH.

- **NEWTON'S THIRD LAW (ACTION-REACTION):** FOR EVERY ACTION, THERE IS AN EQUAL AND OPPOSITE REACTION. THIS MEANS THAT FORCES ALWAYS COME IN PAIRS. IF YOU PUSH ON A WALL, THE WALL PUSHES BACK ON YOU WITH THE SAME AMOUNT OF FORCE. WHEN A ROCKET EXPELS HOT GAS DOWNWARDS, THE GAS PUSHES THE ROCKET UPWARDS.

ENERGY, WORK, AND POWER

THESE CONCEPTS ARE INTRINSICALLY LINKED IN CLASSICAL MECHANICS AND HELP US QUANTIFY THE EFFECTS OF FORCES OVER DISTANCES AND TIME. WORK IS DONE WHEN A FORCE CAUSES AN OBJECT TO MOVE A CERTAIN DISTANCE. IT'S ESSENTIALLY ENERGY TRANSFERRED THROUGH MOTION. FOR INSTANCE, LIFTING A BOX REQUIRES WORK, AND THE ENERGY YOU EXPEND IS STORED IN THE BOX AS POTENTIAL ENERGY.

ENERGY ITSELF IS THE CAPACITY TO DO WORK. IT EXISTS IN MANY FORMS, SUCH AS KINETIC ENERGY (THE ENERGY OF MOTION) AND POTENTIAL ENERGY (STORED ENERGY DUE TO POSITION OR STATE). POWER, ON THE OTHER HAND, IS THE RATE AT WHICH WORK IS DONE OR ENERGY IS TRANSFERRED. A MORE POWERFUL ENGINE CAN DO THE SAME AMOUNT OF WORK IN LESS TIME. SO, IF TWO PEOPLE LIFT THE SAME WEIGHT TO THE SAME HEIGHT, THE ONE WHO DOES IT FASTER HAS MORE POWER.

THERMODYNAMICS: THE SCIENCE OF HEAT AND ENERGY

THERMODYNAMICS DELVES INTO THE RELATIONSHIP BETWEEN HEAT, WORK, TEMPERATURE, AND ENERGY. IT GOVERNS HOW ENERGY IS TRANSFERRED AND TRANSFORMED, AND IT'S FUNDAMENTAL TO UNDERSTANDING EVERYTHING FROM ENGINES TO THE WEATHER TO THE VERY EXISTENCE OF LIFE.

THE LAWS OF THERMODYNAMICS

THERE ARE FOUR FUNDAMENTAL LAWS OF THERMODYNAMICS, EACH BUILDING UPON THE LAST AND OFFERING PROFOUND INSIGHTS INTO THE UNIVERSE'S ENERGY DYNAMICS.

- **THE ZEROETH LAW:** IF TWO THERMODYNAMIC SYSTEMS ARE EACH IN THERMAL EQUILIBRIUM WITH A THIRD SYSTEM, THEN THEY ARE IN THERMAL EQUILIBRIUM WITH EACH OTHER. THIS SOUNDS SIMPLE, BUT IT'S CRUCIAL FOR DEFINING TEMPERATURE – IF TWO OBJECTS ARE AT THE SAME TEMPERATURE, NO HEAT WILL FLOW BETWEEN THEM.
- **THE FIRST LAW (CONSERVATION OF ENERGY):** ENERGY CANNOT BE CREATED OR DESTROYED, ONLY CONVERTED FROM ONE FORM TO ANOTHER. THIS IS A FUNDAMENTAL PRINCIPLE THAT STATES THE TOTAL ENERGY IN AN ISOLATED SYSTEM REMAINS CONSTANT. IT'S A MORE SPECIFIC STATEMENT OF ENERGY CONSERVATION APPLIED TO HEAT AND WORK.
- **THE SECOND LAW:** THE TOTAL ENTROPY OF AN ISOLATED SYSTEM CAN ONLY INCREASE OVER TIME, OR REMAIN CONSTANT IN IDEAL CASES WHERE THE SYSTEM IS IN A STEADY STATE OR UNDERGOING A REVERSIBLE PROCESS. IN SIMPLER TERMS, NATURAL PROCESSES TEND TO MOVE TOWARDS A STATE OF GREATER DISORDER OR RANDOMNESS. THINK ABOUT A PERFECTLY TIDY ROOM THAT NATURALLY BECOMES MESSY OVER TIME; IT TAKES EFFORT TO TIDY IT UP AGAIN.
- **THE THIRD LAW:** AS THE TEMPERATURE OF A SYSTEM APPROACHES ABSOLUTE ZERO (0 KELVIN OR -273.15 DEGREES CELSIUS), THE ENTROPY OF THE SYSTEM APPROACHES A MINIMUM OR ZERO VALUE. THIS IMPLIES THAT ABSOLUTE ZERO IS UNATTAINABLE IN A FINITE NUMBER OF STEPS.

ENTROPY AND THE ARROW OF TIME

ENTROPY IS OFTEN DESCRIBED AS A MEASURE OF DISORDER OR RANDOMNESS IN A SYSTEM. THE SECOND LAW OF THERMODYNAMICS, WITH ITS EMPHASIS ON INCREASING ENTROPY, PROVIDES A FUNDAMENTAL REASON WHY PROCESSES IN THE UNIVERSE SEEM TO HAVE A DIRECTION – A CONCEPT OFTEN REFERRED TO AS THE “ARROW OF TIME.” THINGS BREAK, THEY DON’T SPONTANEOUSLY UN-BREAK. HEAT FLOWS FROM HOT TO COLD, NOT THE OTHER WAY AROUND, UNLESS ENERGY IS EXPENDED TO MAKE IT DO SO. THIS TENDENCY TOWARDS INCREASING ENTROPY IS WHY THE UNIVERSE AS A WHOLE IS CONSTANTLY EVOLVING AND CHANGING.

ELECTROMAGNETISM: THE FORCE UNIFYING ELECTRICITY AND MAGNETISM

ELECTROMAGNETISM IS ONE OF THE FOUR FUNDAMENTAL FORCES OF NATURE. IT DESCRIBES THE INTERACTIONS BETWEEN ELECTRICALLY CHARGED PARTICLES, ENCOMPASSING BOTH ELECTRICITY AND MAGNETISM, WHICH ARE REVEALED TO BE TWO FACETS OF THE SAME PHENOMENON.

ELECTRIC FIELDS AND CHARGES

ELECTRIC CHARGE IS A FUNDAMENTAL PROPERTY OF MATTER. THERE ARE TWO TYPES: POSITIVE AND NEGATIVE. LIKE CHARGES REPEL EACH OTHER, WHILE OPPOSITE CHARGES ATTRACT. AN ELECTRIC FIELD IS A REGION AROUND A CHARGED OBJECT WHERE ANOTHER CHARGED OBJECT WOULD EXPERIENCE A FORCE. THE STRENGTH AND DIRECTION OF THIS FORCE DEPEND ON THE MAGNITUDE AND SIGN OF THE CHARGES AND THE DISTANCE BETWEEN THEM. THINK OF IT LIKE THE GRAVITATIONAL FIELD AROUND THE EARTH, BUT FOR ELECTRIC CHARGES.

MAGNETIC FIELDS AND THEIR INTERACTIONS

MAGNETIC FIELDS ARE GENERATED BY MOVING ELECTRIC CHARGES (ELECTRIC CURRENTS) AND ALSO BY THE INTRINSIC MAGNETIC MOMENTS OF ELEMENTARY PARTICLES. MAGNETS HAVE POLES, TYPICALLY A NORTH AND A SOUTH POLE. LIKE POLES REPEL, AND OPPOSITE POLES ATTRACT. A KEY INSIGHT OF ELECTROMAGNETISM IS THAT A CHANGING MAGNETIC FIELD CAN INDUCE AN ELECTRIC CURRENT, AND AN ELECTRIC CURRENT CREATES A MAGNETIC FIELD. THIS INTERPLAY IS THE BASIS FOR ELECTRIC GENERATORS, MOTORS, AND MUCH OF OUR MODERN TECHNOLOGY.

QUANTUM MECHANICS: THE PHYSICS OF THE VERY SMALL

QUANTUM MECHANICS IS THE THEORY THAT DESCRIBES NATURE AT THE SMALLEST SCALES – THE REALM OF ATOMS AND SUBATOMIC PARTICLES. IT’S A WORLD THAT BEHAVES VERY DIFFERENTLY FROM OUR EVERYDAY EXPERIENCE, OFTEN DEFYING CLASSICAL INTUITION.

WAVE-PARTICLE DUALITY

ONE OF THE MOST ASTONISHING CONCEPTS IN QUANTUM MECHANICS IS WAVE-PARTICLE DUALITY. IT STATES THAT ALL MATTER AND ENERGY EXHIBIT BOTH WAVE-LIKE AND PARTICLE-LIKE PROPERTIES. FOR EXAMPLE, LIGHT, WHICH WE OFTEN THINK OF AS WAVES, CAN ALSO BEHAVE LIKE PARTICLES CALLED PHOTONS. CONVERSELY, PARTICLES LIKE ELECTRONS, WHICH WE CONSIDER TINY BALLS OF MATTER, CAN EXHIBIT WAVE-LIKE BEHAVIOR, SUCH AS DIFFRACTION. THIS DUALITY IS NOT ABOUT AN OBJECT BEING ONE OR THE OTHER, BUT RATHER POSSESSING BOTH CHARACTERISTICS SIMULTANEOUSLY, WITH THE OBSERVED BEHAVIOR DEPENDING ON HOW IT’S MEASURED.

QUANTUM SUPERPOSITION AND ENTANGLEMENT

QUANTUM SUPERPOSITION MEANS THAT A QUANTUM SYSTEM CAN EXIST IN MULTIPLE STATES AT THE SAME TIME UNTIL IT IS

MEASURED. IMAGINE A COIN SPINNING IN THE AIR – IT'S NEITHER HEADS NOR TAILS UNTIL IT LANDS. IN THE QUANTUM WORLD, A PARTICLE CAN BE IN MANY PLACES OR HAVE MANY ENERGIES SIMULTANEOUSLY. QUANTUM ENTANGLEMENT IS AN EVEN MORE PECULIAR PHENOMENON WHERE TWO OR MORE PARTICLES BECOME LINKED IN SUCH A WAY THAT THEY SHARE THE SAME FATE, NO MATTER HOW FAR APART THEY ARE. MEASURING THE STATE OF ONE ENTANGLED PARTICLE INSTANTANEOUSLY INFLUENCES THE STATE OF THE OTHER(S).

RELATIVITY: SPACE, TIME, AND GRAVITY REDEFINED

ALBERT EINSTEIN'S THEORIES OF RELATIVITY REVOLUTIONIZED OUR UNDERSTANDING OF SPACE, TIME, GRAVITY, AND THE UNIVERSE ITSELF, PARTICULARLY AT HIGH SPEEDS AND IN STRONG GRAVITATIONAL FIELDS.

SPECIAL RELATIVITY

SPECIAL RELATIVITY, PUBLISHED IN 1905, DEALS WITH THE RELATIONSHIP BETWEEN SPACE AND TIME FOR OBJECTS MOVING AT CONSTANT SPEEDS IN STRAIGHT LINES. ITS TWO POSTULATES ARE:

- THE LAWS OF PHYSICS ARE THE SAME FOR ALL OBSERVERS IN UNIFORM MOTION (NOT ACCELERATING).
- THE SPEED OF LIGHT IN A VACUUM IS THE SAME FOR ALL OBSERVERS, REGARDLESS OF THEIR MOTION OR THE MOTION OF THE LIGHT SOURCE.

FROM THESE SIMPLE IDEAS, PROFOUND CONSEQUENCES EMERGE, SUCH AS TIME DILATION (TIME PASSES SLOWER FOR A MOVING OBSERVER) AND LENGTH CONTRACTION (OBJECTS APPEAR SHORTER IN THE DIRECTION OF MOTION). IT ALSO FAMOUSLY LEADS TO THE EQUATION $E=mc^2$, SHOWING THE EQUIVALENCE OF MASS AND ENERGY.

GENERAL RELATIVITY

GENERAL RELATIVITY, PUBLISHED IN 1915, EXTENDS SPECIAL RELATIVITY TO INCLUDE ACCELERATION AND GRAVITY. EINSTEIN PROPOSED THAT GRAVITY IS NOT A FORCE IN THE TRADITIONAL SENSE, BUT RATHER A CURVATURE OF SPACETIME CAUSED BY MASS AND ENERGY. IMAGINE PLACING A HEAVY BALL ON A STRETCHED RUBBER SHEET; IT CREATES A DIP. IF YOU ROLL A SMALLER MARBLE NEARBY, IT WILL CURVE TOWARDS THE HEAVY BALL, NOT BECAUSE OF A DIRECT PULL, BUT BECAUSE OF THE WARPED SURFACE. THIS GEOMETRIC INTERPRETATION OF GRAVITY HAS BEEN INCREDIBLY SUCCESSFUL IN EXPLAINING PHENOMENA LIKE THE BENDING OF LIGHT BY MASSIVE OBJECTS AND THE ORBITS OF PLANETS.

EMBARKING ON THE STUDY OF CORE PHYSICS THEORIES IS LIKE ACQUIRING A NEW LENS THROUGH WHICH TO VIEW THE UNIVERSE. FROM THE PREDICTABLE DANCE OF CLASSICAL MECHANICS TO THE MIND-BENDING PROBABILITIES OF QUANTUM MECHANICS, AND THE INTERTWINED FABRIC OF SPACETIME IN RELATIVITY, THESE PRINCIPLES OFFER A FRAMEWORK FOR UNDERSTANDING EXISTENCE ITSELF. EACH THEORY, WHILE DISTINCT, CONTRIBUTES TO A GRANDER, UNIFIED PICTURE OF HOW EVERYTHING WORKS. AS YOU CONTINUE TO EXPLORE, REMEMBER THAT PHYSICS IS A VIBRANT, EVOLVING FIELD, AND THE QUEST TO UNDERSTAND THE COSMOS IS AN ONGOING ADVENTURE.

FREQUENTLY ASKED QUESTIONS

Q: WHAT IS THE MOST FUNDAMENTAL CONCEPT IN CORE PHYSICS THEORIES FOR BEGINNERS?

A: FOR BEGINNERS, THE MOST FUNDAMENTAL CONCEPT IS OFTEN NEWTON'S LAWS OF MOTION, AS THEY PROVIDE A CLEAR AND INTUITIVE UNDERSTANDING OF HOW OBJECTS MOVE AND INTERACT IN OUR EVERYDAY WORLD. THEY ARE THE BEDROCK UPON WHICH MUCH OF CLASSICAL PHYSICS IS BUILT.

Q: HOW DO QUANTUM MECHANICS AND CLASSICAL MECHANICS DIFFER?

A: CLASSICAL MECHANICS DESCRIBES THE MACROSCOPIC WORLD WITH PREDICTABLE LAWS, WHILE QUANTUM MECHANICS GOVERNS THE MICROSCOPIC REALM OF ATOMS AND SUBATOMIC PARTICLES, WHERE PHENOMENA LIKE SUPERPOSITION AND WAVE-PARTICLE DUALITY DEFY CLASSICAL INTUITION AND INTRODUCE INHERENT PROBABILITIES.

Q: IS $E=mc^2$ PART OF CLASSICAL MECHANICS OR RELATIVITY?

A: THE FAMOUS EQUATION $E=mc^2$, WHICH STATES THE EQUIVALENCE OF MASS AND ENERGY, IS A DIRECT CONSEQUENCE OF EINSTEIN'S THEORY OF SPECIAL RELATIVITY. IT'S NOT PART OF CLASSICAL MECHANICS.

Q: WHAT IS THE ROLE OF ENERGY IN THERMODYNAMICS?

A: IN THERMODYNAMICS, ENERGY IS THE CENTRAL CONCEPT. THE LAWS OF THERMODYNAMICS DESCRIBE HOW ENERGY IS TRANSFERRED (AS HEAT OR WORK) AND TRANSFORMED BETWEEN DIFFERENT FORMS, AND HOW THESE PROCESSES AFFECT THE OVERALL STATE OF A SYSTEM, PARTICULARLY IN TERMS OF ENTROPY AND TEMPERATURE.

Q: WHY IS UNDERSTANDING CORE PHYSICS THEORIES IMPORTANT EVEN IF I DON'T PLAN TO BE A PHYSICIST?

A: UNDERSTANDING CORE PHYSICS THEORIES PROVIDES A FRAMEWORK FOR CRITICAL THINKING, PROBLEM-SOLVING, AND APPRECIATING THE NATURAL WORLD AROUND US. IT UNDERLIES MUCH OF MODERN TECHNOLOGY AND SCIENTIFIC PROGRESS, MAKING IT VALUABLE FOR INFORMED CITIZENSHIP AND A DEEPER UNDERSTANDING OF HOW THINGS WORK.

Q: ARE THERE ANY SIMPLE EXPERIMENTS BEGINNERS CAN DO TO EXPLORE CORE PHYSICS THEORIES?

A: YES, MANY BASIC EXPERIMENTS CAN ILLUSTRATE CORE PHYSICS. FOR INSTANCE, OBSERVING HOW OBJECTS ROLL DOWN A RAMP DEMONSTRATES GRAVITY AND ACCELERATION (CLASSICAL MECHANICS), BOILING WATER SHOWS HEAT TRANSFER AND PHASE CHANGES (THERMODYNAMICS), AND PLAYING WITH MAGNETS ILLUSTRATES MAGNETIC FIELDS (ELECTROMAGNETISM).

Q: WHAT IS THE RELATIONSHIP BETWEEN ELECTROMAGNETISM AND LIGHT?

A: LIGHT IS AN ELECTROMAGNETIC WAVE. ELECTROMAGNETISM EXPLAINS HOW ELECTRIC AND MAGNETIC FIELDS OSCILLATE AND PROPAGATE THROUGH SPACE, AND THIS PROPAGATION IS WHAT WE PERCEIVE AS LIGHT. THE SPEED OF LIGHT IS A FUNDAMENTAL CONSTANT IN THIS THEORY.

Q: HOW DOES GENERAL RELATIVITY EXPLAIN GRAVITY DIFFERENTLY FROM NEWTON?

A: NEWTON DESCRIBED GRAVITY AS A FORCE PULLING OBJECTS TOGETHER. EINSTEIN'S GENERAL RELATIVITY EXPLAINS GRAVITY AS THE CURVATURE OF SPACETIME CAUSED BY THE PRESENCE OF MASS AND ENERGY. OBJECTS FOLLOW THE CURVES IN SPACETIME, WHICH WE PERCEIVE AS GRAVITATIONAL ATTRACTION.

[Core Physics Theories For Beginners](#)

Core Physics Theories For Beginners

Related Articles

- [core probability and statistics](#)
- [core physics principles for non-majors us](#)
- [core marketing concepts america](#)

[Back to Home](#)