Inertia, Kepler laws, standing waves, fluid, thermodynamics, electromagnetism

Moment of inertia

hyperphysics.phy-astr.gsu.edu/hbase/mi.html

en.wikipedia.org/wiki/Moment\_of\_inertia

Question:

Give main moments of inertia.

Kepler laws

First law of Kepler says that planets move along elliptical orbits, in foci of which there is the star.

Second law of Kepler says that a planet covers the same area during the same time, moving faster when closer to the star and slower when further from the star.

Third law of Kepler says that period squared, divided by average radius cubed is the constant for all the planets.

Question:

Explain laws of Kepler.

Standing wave

en.wikipedia.org/wiki/Standing\_wave

https://youtube.com/watch?v=0Rfushlee0U

Characteristic equation: L = n(λ/2), n = 1,2,3,…

Waves in ocean can travel a great distance, just like sound waves, but some are confined to a specific region, like if you shake rope with one end fixed in space. Waves will travel down this rope and then back again, reflected at the boundary. Some waves are confined between two fixed boundaries, like string, where they experience reflection at both ends of the string, resulting in a multitude wave cycles, traveling in both directions. If this vibration is of particular frequency, it will produce an interference pattern, that is a stationary wave. These are called transverse standing waves. These kinds of waves can only have particular frequencies for strings of given length because they only have integer numbers of half-wavelengths, since the waves must return to zero amplitude at both boundaries. If the number of half-wavelengths was not an integer, the wave could not exist. This means that number of half-waves must be quantized, meaning, it can only exhibit certain discrete values, set of integers and not from continuous spectrum.

Standing waves contain nodes, where there is destructive interference and amplitude of zero, as well as antinodes, where amplitude is at maximum. The string will be stationary at the nodes and other sections, if vibrating rapidly enough, will appear to human eye to create loops and more nodes mean more energy.

Two-dimensional standing wave also exist. The nodes are lines and curves, in this case.

Standing waves are used in music.

Question:

Fill in the blanks:

Any standing wave must have an integer number of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

In a standing wave, the place with zero amplitude are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

A standing wave with greater frequency corresponds with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ energy.

Electromagnetic interaction is responsible for almost everything in classical physics: friction, elasticity, plasticity, fracture, thermodynamics.

Question:

What force is responsible for almost everything in classical physics: friction, elasticity, plasticity, fracture, thermodynamics?

Question:

How will water level change if all floating icebergs will melt?

If we want to increase thermal exchange, then we stretch, increasing our area.

If we want to decrease thermal exchange, then we contract, decreasing our area.

Question:

Why do cats often stretch in hot places?

Surface area is directly proportional to heat exchange.

Conduction

Conduction is heat transfer in solid.

**Conduction** is the process by which [heat](https://en.wikipedia.org/wiki/Heat) is [transferred](https://en.wikipedia.org/wiki/Heat_transfer) from the hotter end to the colder end of an object. The ability of the object to conduct heat is known as its [*thermal conductivity*](https://en.wikipedia.org/wiki/Thermal_conductivity)

en.wikipedia.org/wiki/Thermal\_conduction

Convection

Convection is heat transfer in fluid.

**Convection** is single or [multiphase](https://en.wikipedia.org/wiki/Multiphase_flow) [fluid flow](https://en.wikipedia.org/wiki/Fluid_flow) that occurs [spontaneously](https://en.wikipedia.org/wiki/Spontaneous_process) due to the combined effects of [material property](https://en.wikipedia.org/wiki/Material_property) [heterogeneity](https://en.wikipedia.org/wiki/Heterogeneity) and [body forces](https://en.wikipedia.org/wiki/Body_forces) on a [fluid](https://en.wikipedia.org/wiki/Fluid), most commonly [density](https://en.wikipedia.org/wiki/Density) and [gravity](https://en.wikipedia.org/wiki/Gravity) (see [buoyancy](https://en.wikipedia.org/wiki/Buoyancy)). When the cause of the convection is unspecified, convection due to the effects of [thermal expansion](https://en.wikipedia.org/wiki/Thermal_expansion) and buoyancy can be assumed. Convection may also take place in soft [solids](https://en.wikipedia.org/wiki/Solids) or [mixtures](https://en.wikipedia.org/wiki/Mixtures) where particles can flow.

Convective flow may be [transient](https://en.wikipedia.org/wiki/Transient_state) (such as when a [multiphase](https://en.wikipedia.org/wiki/Multiphasic_liquid) [mixture](https://en.wikipedia.org/wiki/Mixture) of [oil](https://en.wikipedia.org/wiki/Oil) and [water](https://en.wikipedia.org/wiki/Water) separates) or [steady state](https://en.wikipedia.org/wiki/Steady_state) (see [Convection cell](https://en.wikipedia.org/wiki/Convection_cell)). The convection may be due to [gravitational](https://en.wikipedia.org/wiki/Gravity), [electromagnetic](https://en.wikipedia.org/wiki/Electromagnetism) or [fictitious](https://en.wikipedia.org/wiki/Fictitious_force) body forces. [Heat transfer by natural convection](https://en.wikipedia.org/wiki/Convection_%28heat_transfer%29) plays a role in the structure of [Earth's atmosphere](https://en.wikipedia.org/wiki/Earth%27s_atmosphere), its [oceans](https://en.wikipedia.org/wiki/Oceans), and its [mantle](https://en.wikipedia.org/wiki/Earth%27s_mantle). Discrete convective cells in the atmosphere can be identified by [clouds](https://en.wikipedia.org/wiki/Clouds), with stronger convection resulting in [thunderstorms](https://en.wikipedia.org/wiki/Thunderstorm). Natural convection also plays a role in [stellar physics](https://en.wikipedia.org/wiki/Stellar_physics). Convection is often categorised or described by the main effect causing the convective flow, e.g. Thermal convection.

en.wikipedia.org/wiki/Convection

Radiation

Radiation is heat transfer through vacuum.

**Thermal radiation** is [electromagnetic radiation](https://en.wikipedia.org/wiki/Electromagnetic_radiation) generated by the [thermal motion](https://en.wikipedia.org/wiki/Thermal_motion) of particles in [matter](https://en.wikipedia.org/wiki/Matter). Thermal radiation is generated when heat from the movement of charges in the material (electrons and protons in common forms of matter) is converted to electromagnetic radiation. All matter with a [temperature](https://en.wikipedia.org/wiki/Temperature) greater than [absolute zero](https://en.wikipedia.org/wiki/Absolute_zero) emits thermal radiation. At [room temperature](https://en.wikipedia.org/wiki/Room_temperature), most of the emission is in the infrared (IR) spectrum. Particle motion results in [charge-acceleration](https://en.wikipedia.org/wiki/Larmor_formula) or [dipole](https://en.wikipedia.org/wiki/Dipole) oscillation which produces electromagnetic radiation.

Infrared radiation emitted by animals (detectable with an [infrared camera](https://en.wikipedia.org/wiki/Infrared_camera)) and [cosmic microwave background radiation](https://en.wikipedia.org/wiki/Cosmic_microwave_background_radiation) are examples of thermal radiation.

If a radiation object meets the physical characteristics of a [black body](https://en.wikipedia.org/wiki/Black_body) in [thermodynamic equilibrium](https://en.wikipedia.org/wiki/Thermodynamic_equilibrium), the radiation is called [blackbody radiation](https://en.wikipedia.org/wiki/Black-body_radiation). [Planck's law](https://en.wikipedia.org/wiki/Planck%27s_law) describes the spectrum of blackbody radiation, which depends solely on the object's temperature. [Wien's displacement law](https://en.wikipedia.org/wiki/Wien%27s_displacement_law) determines the most likely frequency of the emitted radiation, and the [Stefan–Boltzmann law](https://en.wikipedia.org/wiki/Stefan%E2%80%93Boltzmann_law) gives the radiant intensity.

Thermal radiation is also one of the fundamental mechanisms of [heat transfer](https://en.wikipedia.org/wiki/Heat_transfer).

en.wikipedia.org/wiki/Thermal\_radiation

Thermodynamics laws

The zeroth law states that if two [thermodynamic systems](https://en.wikipedia.org/wiki/Thermodynamic_system) are both in [thermal equilibrium](https://en.wikipedia.org/wiki/Thermal_equilibrium) with a third system, then the two systems are in thermal equilibrium with each other.

en.wikipedia.org/wiki/Zeroth\_law\_of\_thermodynamics

The **first law of thermodynamics** is a formulation of the law of [conservation of energy](https://en.wikipedia.org/wiki/Conservation_of_energy) in the context of [thermodynamic processes](https://en.wikipedia.org/wiki/Thermodynamic_process) in which two principle forms of energy transfer, [heat](https://en.wikipedia.org/wiki/Heat) and [thermodynamic work](https://en.wikipedia.org/wiki/Work_%28thermodynamics%29), are distinguished that modify a [thermodynamic system](https://en.wikipedia.org/wiki/Thermodynamic_system) of a constant amount of matter. The law also defines the [internal energy](https://en.wikipedia.org/wiki/Internal_energy) of a system, an [extensive property](https://en.wikipedia.org/wiki/Extensive_property) for taking account of the balance of these energies in the system. Energy cannot be created or destroyed, but it can be transformed from one form to another. In an [isolated system](https://en.wikipedia.org/wiki/Isolated_system) the sum of all forms of energy is constant.

en.wikipedia.org/wiki/First\_law\_of\_thermodynamics

The **second law of thermodynamics** is a [physical law](https://en.wikipedia.org/wiki/Physical_law) based on universal experience concerning [heat](https://en.wikipedia.org/wiki/Heat) and [energy interconversions](https://en.wikipedia.org/wiki/Energy_transformation). A simple statement of the law is that heat always flows spontaneously from hotter to colder regions of matter (or 'downhill' in terms of the temperature gradient). Another statement is: "Not all heat can be converted into [work](https://en.wikipedia.org/wiki/Work_%28thermodynamics%29) in a [cyclic process](https://en.wikipedia.org/wiki/Cyclic_process)."

The second law of thermodynamics establishes the concept of [entropy](https://en.wikipedia.org/wiki/Entropy) as a physical property of a [thermodynamic system](https://en.wikipedia.org/wiki/Thermodynamic_system). It predicts whether processes are forbidden despite obeying the requirement of [conservation of energy](https://en.wikipedia.org/wiki/Conservation_of_energy) as expressed in the [first law of thermodynamics](https://en.wikipedia.org/wiki/First_law_of_thermodynamics) and provides necessary criteria for [spontaneous processes](https://en.wikipedia.org/wiki/Spontaneous_process). For example, the first law allows the process of a cup falling off of a table and breaking on the floor, as well as allowing the reverse process of the cup fragments coming back together and 'jumping' back onto the table, while the second law allows the former and denies the latter. The second law may be formulated by the observation that the entropy of [isolated systems](https://en.wikipedia.org/wiki/Isolated_system) left to spontaneous evolution cannot decrease, as they always tend toward a state of [thermodynamic equilibrium](https://en.wikipedia.org/wiki/Thermodynamic_equilibrium) where the entropy is highest at the given internal energy. An increase in the combined entropy of system and surroundings accounts for the [irreversibility](https://en.wikipedia.org/wiki/Irreversibility) of natural processes, often referred to in the concept of the [arrow of time](https://en.wikipedia.org/wiki/Arrow_of_time).

Historically, the second law was an [empirical finding](https://en.wikipedia.org/wiki/Empirical_evidence) that was accepted as an [axiom](https://en.wikipedia.org/wiki/Axiom) of [thermodynamic theory](https://en.wikipedia.org/wiki/Thermodynamics). [Statistical mechanics](https://en.wikipedia.org/wiki/Statistical_mechanics) provides a microscopic explanation of the law in terms of [probability distributions](https://en.wikipedia.org/wiki/Probability_distribution) of the states of large assemblies of [atoms](https://en.wikipedia.org/wiki/Atom) or [molecules](https://en.wikipedia.org/wiki/Molecule). The second law has been expressed in many ways. Its first formulation, which preceded the proper definition of entropy and was based on [caloric theory](https://en.wikipedia.org/wiki/Caloric_theory), is [Carnot's theorem](https://en.wikipedia.org/wiki/Carnot%27s_theorem_%28thermodynamics%29), formulated by the French scientist [Sadi Carnot](https://en.wikipedia.org/wiki/Nicolas_L%C3%A9onard_Sadi_Carnot), who in 1824 showed that the efficiency of conversion of heat to work in a heat engine has an upper limit. The first rigorous definition of the second law based on the concept of entropy came from German scientist [Rudolf Clausius](https://en.wikipedia.org/wiki/Rudolf_Clausius) in the 1850s and included his statement that heat can never pass from a colder to a warmer body without some other change, connected therewith, occurring at the same time.

The second law of thermodynamics allows the definition of the concept of [thermodynamic temperature](https://en.wikipedia.org/wiki/Thermodynamic_temperature), but this has been formally delegated to the [zeroth law of thermodynamics](https://en.wikipedia.org/wiki/Zeroth_law_of_thermodynamics).

en.wikipedia.org/wiki/Second\_law\_of\_thermodynamics

The **third law of thermodynamics** states that the entropy of a closed system at [thermodynamic equilibrium](https://en.wikipedia.org/wiki/Thermodynamic_equilibrium) approaches a constant value when its temperature approaches [absolute zero](https://en.wikipedia.org/wiki/Absolute_zero). This constant value cannot depend on any other parameters characterizing the system, such as pressure or applied magnetic field. At absolute zero (zero [kelvins](https://en.wikipedia.org/wiki/Kelvin)) the system must be in a state with the minimum possible energy.

Entropy is related to the number of accessible [microstates](https://en.wikipedia.org/wiki/Microstate_%28statistical_mechanics%29), and there is typically one unique state (called the [ground state](https://en.wikipedia.org/wiki/Ground_state)) with minimum energy. In such a case, the entropy at absolute zero will be exactly zero. If the system does not have a well-defined order (if its order is [glassy](https://en.wikipedia.org/wiki/Amorphous_solid), for example), then there may remain some finite entropy as the system is brought to very low temperatures, either because the system becomes locked into a configuration with non-minimal energy or because the minimum energy state is non-unique. The constant value is called the [residual entropy](https://en.wikipedia.org/wiki/Residual_entropy) of the system. The entropy is essentially a state-function meaning the inherent value of different atoms, molecules, and other configurations of particles including subatomic or atomic material is defined by entropy, which can be discovered near 0 K.

en.wikipedia.org/wiki/Third\_law\_of\_thermodynamics

Question:

Explain laws of thermodynamics.

Work of gas

For a gas, work is the product of the pressure p and the volume V during a change of volume. On a graph of pressure versus volume, the work is the area under the curve that describes how the state is changed from State 1 to State 2.

Heat energy

All matter contains heat energy. Heat energy is the result of the movement of tiny particles called atoms, molecules or ions in solids, liquids and gases. Heat energy can be transferred from one object to another. The transfer or flow due to the difference in temperature between the two objects is called heat.

Internal energy

The **internal energy** of a [thermodynamic system](https://en.wikipedia.org/wiki/Thermodynamic_system) is the [energy](https://en.wikipedia.org/wiki/Energy) contained within it, measured as the quantity of energy necessary to bring the system from its [standard](https://en.wikipedia.org/wiki/Standard_state) internal state to its present internal state of interest, accounting for the gains and losses of energy due to changes in its internal state, including such quantities as [magnetization](https://en.wikipedia.org/wiki/Magnetization). It excludes the [kinetic energy](https://en.wikipedia.org/wiki/Kinetic_energy) of motion of the system as a whole and the [potential energy](https://en.wikipedia.org/wiki/Potential_energy) of position of the system as a whole, with respect to its surroundings and external force fields. It includes the thermal energy, *i.e.*, the constituent particles' kinetic energies of motion relative to the motion of the system as a whole. The internal energy of an [isolated](https://en.wikipedia.org/wiki/Thermodynamic_system#Isolated_system) system cannot change, as expressed in the law of [conservation of energy](https://en.wikipedia.org/wiki/Conservation_of_energy), a foundation of the [first law of thermodynamics](https://en.wikipedia.org/wiki/First_law_of_thermodynamics).

The internal energy cannot be measured absolutely. Thermodynamics concerns *changes* in the internal energy, not its absolute value. The processes that change the internal energy are transfers, into or out of the system, of matter, or of energy, as [heat](https://en.wikipedia.org/wiki/Heat), or by [thermodynamic work](https://en.wikipedia.org/wiki/Work_%28thermodynamics%29). These processes are measured by changes in the system's properties, such as temperature, [entropy](https://en.wikipedia.org/wiki/Entropy), volume, electric polarization, and [molar constitution](https://en.wikipedia.org/wiki/Chemical_composition). The internal energy depends only on the internal state of the system and not on the particular choice from many possible processes by which energy may pass into or out of the system. It is a [state variable](https://en.wikipedia.org/wiki/State_function), a [thermodynamic potential](https://en.wikipedia.org/wiki/Thermodynamic_potential), and an [extensive property](https://en.wikipedia.org/wiki/Intensive_and_extensive_properties).

Thermodynamics defines internal energy macroscopically, for the body as a whole. In [statistical mechanics](https://en.wikipedia.org/wiki/Statistical_physics), the internal energy of a body can be analyzed microscopically in terms of the kinetic energies of microscopic motion of the system's particles from [translations](https://en.wikipedia.org/wiki/Translation_%28physics%29), [rotations](https://en.wikipedia.org/wiki/Rotation), and [vibrations](https://en.wikipedia.org/wiki/Oscillation), and of the potential energies associated with microscopic forces, including [chemical bonds](https://en.wikipedia.org/wiki/Chemical_bonds).

The unit of [energy](https://en.wikipedia.org/wiki/Energy) in the [International System of Units](https://en.wikipedia.org/wiki/International_System_of_Units) (SI) is the [joule](https://en.wikipedia.org/wiki/Joule) (J). The internal energy relative to the [mass](https://en.wikipedia.org/wiki/Mass) with unit J/kg is the *specific internal energy*. The corresponding quantity relative to the [amount of substance](https://en.wikipedia.org/wiki/Amount_of_substance) with unit J/[mol](https://en.wikipedia.org/wiki/Mole_%28unit%29) is the *molar internal energy*.

Isothermal process

youtube.com/watch?v=8y5KX4kzt0A

Isobaric process

youtube.com/watch?v=AzmXVvxXN70

Isochoric process

youtube.com/watch?v=vV1fGs3JKzU

Adiabatic process

youtube.com/watch?v=gaZmZjBtgAM

Carnot cycle

A **Carnot cycle** is an ideal [thermodynamic cycle](https://en.wikipedia.org/wiki/Thermodynamic_cycle) proposed by French physicist [Sadi Carnot](https://en.wikipedia.org/wiki/Nicolas_L%C3%A9onard_Sadi_Carnot) in 1824 and expanded upon by others in the 1830s and 1840s. By [Carnot's theorem](https://en.wikipedia.org/wiki/Carnot%27s_theorem_%28thermodynamics%29), it provides an upper limit on the [efficiency](https://en.wikipedia.org/wiki/Thermal_efficiency) of any classical [thermodynamic engine](https://en.wikipedia.org/wiki/Heat_engine) during the conversion of [heat](https://en.wikipedia.org/wiki/Heat) into [work](https://en.wikipedia.org/wiki/Work_%28thermodynamics%29), or conversely, the efficiency of a [refrigeration](https://en.wikipedia.org/wiki/Refrigeration) system in creating a temperature difference through the application of work to the system.

en.wikipedia.org/wiki/Carnot\_cycle

Otto cycle

An **Otto cycle** is an idealized [thermodynamic cycle](https://en.wikipedia.org/wiki/Thermodynamic_cycle) that describes the functioning of a typical [spark ignition](https://en.wikipedia.org/wiki/Spark-ignition_engine) [piston engine](https://en.wikipedia.org/wiki/Piston_engine). It is the thermodynamic cycle most commonly found in automobile engines.

The Otto cycle is a description of what happens to a gas as it is subjected to changes of pressure, temperature, volume, addition of heat, and removal of heat. The gas that is subjected to those changes is called the system. The system, in this case, is defined to be the fluid (gas) within the cylinder. By describing the changes that take place within the system, it will also describe in inverse, the system's effect on the environment. In the case of the Otto cycle, the effect will be to produce enough net work from the system so as to propel an automobile and its occupants in the environment.

en.wikipedia.org/wiki/Otto\_cycle

Lorentz force

In [physics](https://en.wikipedia.org/wiki/Physics) (specifically in [electromagnetism](https://en.wikipedia.org/wiki/Electromagnetism)), the **Lorentz force** (or **electromagnetic force**) is the combination of electric and magnetic [force](https://en.wikipedia.org/wiki/Force) on a [point charge](https://en.wikipedia.org/wiki/Point_charge) due to [electromagnetic fields](https://en.wikipedia.org/wiki/Electromagnetic_field).

en.wikipedia.org/wiki/Lorentz\_force