Physics

1. Definition of mechanical energy

A: The general form of the definition for **mechanical energy** is: $E_{mech} = K + PE$
Where:
PE refers to the total potential energy of the system, including all types of potential energy; [J]
K refers to the sum of the kinetic energies of all particles in the system, [J]
E_{mech} is the total mechanic energy ; [J]

2. Definition of the kinetic energy

A: The **kinetic energy** *K* of an object of mass m moving with a speed v is defined as $K = ½ (mv^2)$
K is the kinetic energy of the moving object [J]
m is the mass of the moving object [kg]
v is the speed of the object [m/s]

3. Definition of work

A. The **work** *W* done on a system by an external agent exerting a **constant force** on the system is the product of the magnitude *F* of the force, the magnitude Δr of the displacement of the point of application of the force, and cos θ,
where θ is the angle between the force and displacement vectors. The work is a scalar quantity.
W is the work [J]
F is the constant external force acting on the system [N]
Δr is the magnitude of the displacement, [m]
The work done by a **variable net force** is

$$\sum W = W_{\text{net}} = \int \left(\sum \vec{\mathbf{F}} \right) \cdot d\vec{\mathbf{r}}$$

where the integral is calculated over the path that the particle takes through space.

4. Definition of potential energy

A: The expression of **potential energy**, in linear systems, is a function of position (relative position). The corresponding force is also a function of position.
The **gravitational potential energy PE** is the energy that an object of mass *m* has by virtue of its position relative to the surface of the earth. That position is measured by the height *h* of the object relative to an arbitrary zero level: PE = mgh
PE is the gravitational potential energy [J]
m is the mass [kg]
g is the gravitational acceleration [m/s^2]
h is the height [m]

5. Definition of (mechanical) power

A: **Power** is the rate at which energy is expended or converted to another form.
Mechanically, it is the rate at which work is done. Power is work done per unit time.
Average power: P = W/t = work[J]/time[s] .
SI Unit for power is the watt: 1W=1J/1s

6. Definition of heat

Heat is energy that flows from a higher-temperature object to a lower-temperature object because of the difference in temperatures. The substance has internal energy, not heat. The word "**heat**" is used only when referring to the energy actually in transit from hot to cold.
SI Unit of Heat: joule (J)

7. Conservation of mechanical energy

A: For an **isolated system** the energy in the system is conserved and the sum of the kinetic and potential energies remains constant. KE + PE = constant

The **total mechanical energy**, E_{mech} = KE + PE of an object remains constant as the object moves, provided that the net work done by external nonconservative forces is zero, $W_{nc}=0$.

8. Conservation of linear momentum (impulse) for an isolated system

A: The **linear momentum** of a particle or an object that can be modeled as a particle of mass m moving with a velocity $\bar{v}$ is defined to be the product of the mass and velocity: $\bar{p} = m\bar{v}$.

The **total linear momentum** of an isolated (net external force equal to zero) system remains constant.

$$\sum \bar{F} = \frac{d\bar{p}}{dt} = 0; \qquad \bar{p}_{tot} = \text{constant}$$

9. The conservation of the angular momentum

The **instantaneous angular momentum** of the particle relative to the origin O is defined by the vector $\bar{L}$ product of its instantaneous position vector $\bar{r}$ and the instantaneous linear momentum $\bar{p}$.

$$\bar{L} = \bar{r} \times \bar{p}$$

The **total angular momentum** of a system is conserved if the net external torque acting on the system is zero.

$$\overline{M}_{ext} = \bar{r} \times \overline{F_{ext}} \qquad \overline{M} = \frac{d\bar{L}}{dt} \qquad \text{External } \overline{M} = 0, \rightarrow \frac{d\bar{L}}{dt} = 0, \rightarrow \bar{L} = \textbf{constant}$$

10. The Hooke's law

A: The force of an elastic system (spring), inside the limits of linearity (elasticity) is given by

$$\bar{F} = -k\bar{x}$$

Where $\boldsymbol{x}$ is the displacement of the spring's end from its equilibrium position (a distance, in SI units: m);

$\boldsymbol{F}$ is the restoring force exerted by the material (in SI units: N or $kgms^{-2}$); and

k is a constant called the ***rate*** or ***spring constant*** (in SI units: $N \cdot m^{-1}$ or kgs^{-2}).

For an elastic bar: $$\Delta l = \frac{F \cdot l_0}{S \cdot E}$$

Where F is the force [N] , l_0 is the initial length of the bar [m], S is the cross section of the bar [m^2] and E is the Young' module (elasticity) of the material of the bar [N/m^2].

11. Archimedes's law:

A: The apparent loss in weight of a body immersed in a fluid is equal to the weight of the displaced fluid

Or: a body immersed in a fluid is pushed up, in the vertical direction, with a force equal to the weight of the volume of the displaced fluid.

12. The law of absorption of waves

A: In a homogenous dissipative media the intensity of plane waves reduces exponentially with the distance

$$I = I_0 e^{-kx}$$

where I_0 is the intensity of the penetrating wave, I is the intensity of the wave at distance x, and k is the absorption coefficient.

The absorption coefficient is a characteristic of the medium, depending also on the wave length of the incident wave

The intensity „I" of the wave is numerically equal to the energy carried by the wave in a second, trough the surface normal (orthogonal on the wave direction of propagation.

13. The reflection laws:
The incident ray, the reflected ray, and the normal to the surface all lie in the same plane, and the angle of reflection equals the angle of incidence .

14. The refraction laws:
When light travels from a material with refractive index n_1 into a material with refractive index n_2, the refracted ray, the incident ray, and the normal to the interface between the materials all lie in the same plane. The angle of refraction is related to the angle of incidence by $n_1 \cdot \sin\theta_1 = n_2 \cdot \sin\theta_2$.

The index of refraction n of a material is the ratio of the speed c of light in a vacuum to the speed v of light in the material.

15. Coulomb's law
A: The magnitude F of the electrostatic force exerted by one point charge q_1 on another point charge q_2 is directly proportional to the magnitudes $|q_1|$ and $|q_2|$ of the charges and inversely proportional to the square of the distance r between them.

$$F = \frac{q_1 \cdot q_2}{4\pi\varepsilon} \cdot \frac{1}{r^2}$$

The electrostatic force is directed along the line joining the charges, and it is attractive if the charges have unlike signs and repulsive if the charges have like signs.