Kinetic and potential energy applications

Contents

Therapy

Radioiodine therapy

Practical Applications

Ultra sound

Diagnostic applications

Therapeutic applications

Total internal reflection

Optic fiber

Ultra violet

X rays

Gamma Rays

References

Wave Theory

Light

Light is a component of spectrum and spectrum is combination of waves. Waves include visible light, x rays, gamma rays, radio waves and micro waves. According to Huygens' Principle, light is made up of waves propagating up and down perpendicular to the direction of travel. (Huygens, 1678)

Endoscopy

An endoscope is basically a flexible tube doctors use to look inside the human body. This flexible tube consists of two or three optical fibers. One or two tubes are used to carry light down into the patient's body while the other is used to carry the reflected light back. The basic principal behind working of endoscope is total internal reflection which is in accordance with the wave nature of light as per wave theory.

Sound

Sound is produced by vibrations. When a body vibrates, it causes its surroundings to vibrate as well. These vibrations produce travelling longitudinal waves. These waves consist of compressions and rarefactions. When these vibrations are produced inside a tube, they are called standing waves. Standing waves result from off the tube end and interfering with itself. Only the waves that fit tube resonate are heard while others frequencies are lost. This nature of sound serves as the working principle of many instruments.

Stethoscope

A stethoscope is a device used by doctors to listen to internal sounds from

- Human body
- Animal bodies
- Blood pressure

A typical stethoscope consists of a round shaped resonator with a tube. The resonator is placed on chest while the tubes are connected to ears to check any variations in sound.

The basic working principle behind a stethoscope is that when it is placed on the chest, vibrations occur at the resonator’s face because of the sound waves being generated from human’s body. These vibrations are carried to tube where through multiple reflections, waves reach the ear. Resonating waves are heard at the ear while other frequencies are lost.

Kinetic and potential energy

Energy can take several forms such as energy to height, energy due to position, thermal energy etc. Kinetic energy is the energy possessed by a body by virtue of its motion while potential energy is the stored energy because of the body’s position. As stated, the energy can take several forms but the total mechanical energy of a system remains conserved. However, the kinetic and potential energy changes throughout the motion are not conserved separately.

Conservative system

A conservative system is a system that can store energy as potential energy and can give that energy back in the form of kinetic energy. Nearly all mechanical systems undergo energy transformation between kinetic and potential energies when certain work is done on them.

Hence in gravitational systems, the following always holds true:

$$E = K.E. + P.E. = \frac{1}{2} mv^2 + \rho gh \text{ (law of conservation of energy)}$$

That is the total mechanical energy of a system is always equal to the sum of kinetic energy and potential energy and hence is in accordance with law of conservation of energy which states that energy can neither be created nor be destroyed but it can be converted from form to another. Hence, at the top, the system possesses only potential energy due to height and when it comes to the ground, all the potential energy is changed to kinetic energy and the work done along the path is path independent and is always equal to zero.

This conservation principle has many practical implications. From our day to day life to energy generation, this principle is extensively employed. Water in a dam has gravitational potential energy stored. When it falls, the potential energy gets converted to kinetic energy and the turbine moves to produce electricity. This energy conservation principle is gaining its ground in the medical field as well.

Conservation of energy in ambulation

Bones and muscles help body in moving forward. During the body motion, energy is being converted from potential to kinetic energy and then back to potential energy. This energy consumption would be least if the body locomotion is in a straight line. However, this doesn’t hold true and hence the body does not proceed at a constant velocity. (Inman, 1968: 26)

To move forward, the force must be exerted against a fixed point because there is always an equal and opposite reaction for a force exerted. In human locomotion, the opposite force is the force exerted by the floor. The changes in the body force being exerted and the reaction during motion can be recorded by a force plate. When the foot strikes, the reaction from the ground increases and a force greater than body weight is exerted. The center of gravity declines and the body weight reduces to 40 percent. Then as the foot is raised, ground reaction becomes greater than the body force. When the body is exerting a force on the ground, there is a negative shear. When the body is passing over the legs, there is no shear and during the opposite reaction, the shear is positive. During the locomotion, as the body is moving up and down and its horizontal velocity is changing as well, the energy is being converted from potential to kinetic and then back to potential. (Inman, 1968: 27)

The problem arises during the double weight bearing phase. There are two shears on the floor in this phase and these results in a force couple acting on the pelvis. This force causes pelvis to rotate in one direction first and then in the other direction later. At the end of the stance phase, velocity of the body increases in the forward direction while backward leg is reaccelerated to zero velocity. The force at the end of stance phase comes from this de acceleration. Output from the calf group muscle must not increase and contribute increasing velocity. This misunderstanding creates problem prostheses fitting to amputees. The artificial leg feels heavier than the normal leg for the amputee and if there is a little weight, the amputee can't develop enough kinetic energy towards the end phase to have high forward speed. Conversely, if the leg is too heavy, the amputee will require a lot of energy to push forward.

The leg should feel lighter at the beginning of the swing phase and heavier at the end of the swing. Ideal human locomotion must follow a sinusoidal curve and there must be a compromise between the weight changes when an amputee moves. Hence during the design, vertical sinusoidal displacement and oscillatory velocity must be made sure to have a better line of progression. This way, we can save almost half the energy when potential energy is being converted to kinetic energy and vice versa (Inman, 1968: 34).

Safety Regulations and Procedures on hazard reduction for Radioactivity

Regulators

If we talk about the America, the primary regulatory agency is nuclear regulatory commission. This regulatory body sets the maximum exposure limit for public and also devises limitations and standards for nuclear industries so that safety measures are being followed. The regulations are of two types: occupational and non-occupational. For occupationally exposed workers such as doctors, the safety limit is 5 rem a year. For general public, the safety limit is 100 mrem. These regulators ensure that nuclear facilities are licensed and are following standards to ensure safety standards. In addition to this regulatory body, there are departments at states and municipal level with hazmat teams to ensure general public and workers safety.

Safety Procedures

- Use time, shielding, containment and distance to reduce exposure. It is a standard practice to place the radioactive material behind a protective shield to reduce the exposure. Occupationally exposed workers must plan their work before entering the field to minimize their exposure time and hence the safety limits. The worker should use handling devices to interact with radioactive materials to ensure a safe distance from the source. Safety level increases by distance squared. (Industrial safety and hygiene news. 2014)

- Workers must wear dosimeter badges. These devices help in measuring the level of external exposure of radioactive material. Commonly used badges are film badge, thermo luminescent badge, optically stimulated badge and electronic dosimeters. These devices indicate if the safety limit has been exceeded or not. They get dark, emit light, emit blue light or show the exposure level against a scale. This also helps in radiological monitoring which is a recommended practice before leaving the work place. Alongside this, these devices also help in keeping a permanent record of radioactive exposure of the worker (Industrial safety and hygiene news. 2014).
- Protective clothing as recommended by the work place must be worn to avoid contact. Despite the protective clothing, if the body comes in contact with radioactive materials, it is recommended to wash the body part with non-abrasive soap and water (Industrial safety and hygiene news. 2014).

Radioactivity in medicine

Nuclear medicine is a field where radioactive materials are used in trace amounts to diagnose and treat many health issues. This field has applications nearly for all body parts such as cardiology, neurology, infection etc. radioisotopes are effective because they different body parts respond differently to different organs and these techniques provide detailed diagnostic details at a very early stage; helping in improved patient management and opting a proper therapeutic approach.

Diagnostic techniques

Radioactive materials that decay with gamma or positron are used with scanning devices to take images of inside body parts for diagnostic purposes. Diagnostic techniques use special devices to capture the body image. Depending upon the application, a pharmaceutical is injected in three ways; injection, inhalation or infestations. The medicine injected in the body helps in tracing and mapping the concerned area and produces a visual representation through a computer. Commonly used diagnostic techniques are scintigraphy and positron emission tomography.

Scintigraphy

It is a two-dimensional diagnostic technique. The radioactive material is injected in the body. This material emits gamma rays that are captured by detectors. These detectors are called gamma cameras; and form a two-dimensional image of the concerned body part. These images can be taken from different angles as well by single photon emission computed tomography (SPECT). This technique makes 3D visualization of the body parts possible.

Positron emission tomography

This technique is similar to SPECT used for detection of cancer cells. This technique uses isotopes that decay faster and produced rays travel in the opposite directions. This helps in 3D visualization of the body parts. These 3D images combined with hybrid cameras and imaging techniques helps in highlighting body part in which pharmaceutical is concentrated. This practice is also called image fusion. Image fusion helps in detailed and better specifications of medical reports.

Radioactive Cobalt

Radioactive cobalt is used to diagnose vitamin B absorption defects. It is injected into the body and the physician can spot any irregularities in the human body through imaging.

Therapy

Radiotherapy is the field of medicine where ionizing radiations are used to treat ontological disease. Radiotherapy is further classified in two types:

- External Beam Radiotherapy: Radioactive source is placed outside human body and radiations are targeted at a specific body part only.
- Sealed source: The radioactive source is placed inside the body; in direct contact with target part.

Radioiodine therapy

Radioiodine therapy is used for treatment of overactive thyroid. Thyroid glands are responsible for producing hormones that regulate human metabolism. When these glands are overactive, the metabolism process becomes faster. Radioiodine emits radiations. This isotope is injected into blood in GI tract and comes in contact with thyroid gland and begins destroying diseased cells.

Practical Applications

Ultra sound

Diagnostic applications

- Sonar principle: Sonography is used to have a visual representation of the echo. The wave travels, strikes any obstacle and comes back travelling some distance. This helps in determining spatial positions. This technology can be used to detect heart valve movement.

- Doppler Effect: With moving particle reflection, additional diagnostic information such as flow properties of blood carrying vessels.

Therapeutic applications

- Thermal and mechanical effects of ultrasound are used in tumor therapy.
- Low frequency ultrasound is used in treating wounds and dentistry.

Total internal reflection

Optic fiber

- Optical fibers are constructed on the principle of total internal reflection. These are used to view inaccessible places and hence find a great use in medicine.
- Fiber optic cable is used in endoscopy; a technique doctors use to examine stomach usually.

Ultra violet

- Ultra violet has found a great use in medicine as well. It is extensively used in killing bacteria and hence finds major application in sterilizing the surfaces.
- These radiations are also used in microbiological laboratories for research purposes. It kills bacteria by deactivating DNA; hence leaving them unable to reproduce.
- UV is also used in water treatment plants as well for purification purposes.

X rays

- The most common use of x rays in medicine is checking for broken bones. Different body tissues absorb different amount of radiations and hence appear differently on an x ray image. Bones appear white because they absorb maximum while lungs look black air absorbs no radiation.
- X rays are also used for identifying pneumonia and breast cancer.

Gamma Rays

- Gamma rays are used in radiation therapy. High doses of gamma rays are used to kill cancerous cells in living organisms.
- These rays are also used in medical equipment sterilization.

References

- Reducing radiation hazards: Industrial safety and hygiene (2014)
- https://www. mirion. com/learning-center/radiation-safety-basics/government-regulation-of-radiation-exposure
- http://www. 3rd1000. com/nuclear/nuke101l. htm
- https://www. iaea. org/sites/default/files/nuclear-medicine-for-diagnosis-and-treatment. pdf
- http://www. aots. sanita. fvg. it/aots/InfoCMS/RepositPubbl/table35/32/Allegati/radiotherapy. pdf
- https://www. physics. ohio-state. edu/~gan/teaching/spring99/C8. pdf
- Verne T. Inman (1968) conservation of energy in ambulation, San Francisco: University of California medical Centre.

- https://www. ssk. de/SharedDocs/Beratungsergebnisse_PDF/2012/Ultraschall_e. pdf?__blob= publicationFile
- https://www. aplustopper. com/applications-total-internal-reflection/
- https://www. leaf. tv/articles/medical-use-of-ultraviolet-lights/
- https://www. larsonelectronics. com/a-149-practical-applications-of-ultraviolet-light. aspx
- https://medlineplus. gov/xrays. html
- https://www. wikilectures. eu/w/Gamma_Rays_and_Medicine
- http://www. nightlase. com. au/education/optics/light. htm
- https://brainly. in/question/921100
- https://steemit. com/stemng/@emmatech/the-science-and-working-principle-of-stethoscope