10.017 Technological World

Problem statement:
How might we leverage on the hostel park to create a space where busy students can go to relax and de-stress.

Physics concept :

1. Thin film Interference :

Thin-film interference arises when light waves reflect off the top and bottom surfaces of a thin film, interfering with each other due to the difference in path lengths. This phenomenon occurs when the thickness of the film is comparable to the wavelength of light. When white light hits the film, certain wavelengths experience constructive interference, intensifying reflection, while others undergo destructive interference, diminishing reflection. As a result, colourful patterns are observed due to the varying reflection intensities at different wavelengths

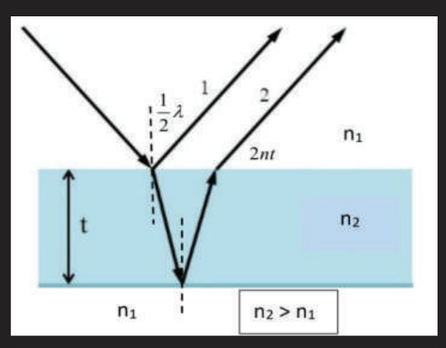
$$\Delta x = 2nt - \frac{1}{2}\lambda$$

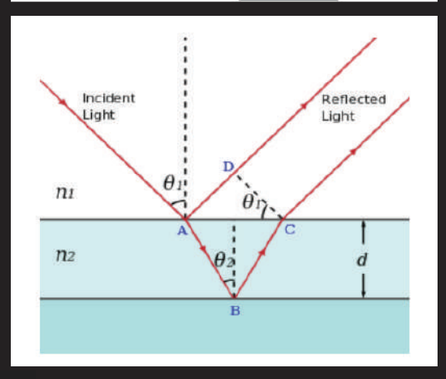
i) Thickness for constructive interference,

$$2nt = \left(m + \frac{1}{2}\right)\lambda \; ; m = 0, 1, 2, 3 \ldots ; n_1 = n$$

ii) Thickness for destructive interference,

$$2nt = (m + 1)\lambda \; ; m = 0, 1, 2, 3 \ldots ; n_1 = n$$





Factors influencing this phase difference include the film thickness, refractive index, and angle of incidence. A phase shift of 180° may occur upon reflection, depending on the refractive indices of the materials. The resulting interference pattern can manifest as either light and dark bands or colourful bands, depending on the incident light source.

The optical path difference (OPD) of the reflected light must be calculated in order to determine the condition for interference. The OPD between the two waves is the following:

$$OPD = n_2(\overline{AB} + \overline{BC}) - n_1(\overline{AD})$$

where,

$$\overline{AB} = \overline{BC} = \frac{d}{\cos\theta_2}$$

$$\overline{AD} = 2d \tan\theta_2 \sin\theta_1$$

Using Snell's Law, $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$$OPD = n_2\left(\frac{2d}{\cos\theta_2}\right) - 2d\tan(\theta_2)n_2\sin(\theta_2)$$

$$= 2n_2 d\left(\frac{1 - sin^2(\theta_2)}{\cos(\theta_2)}\right)$$

$$= 2n_2 d\cos(\theta_2)$$

Interference will be constructive if the optical path difference is equal to an integer multiple of the wavelength of light, λ

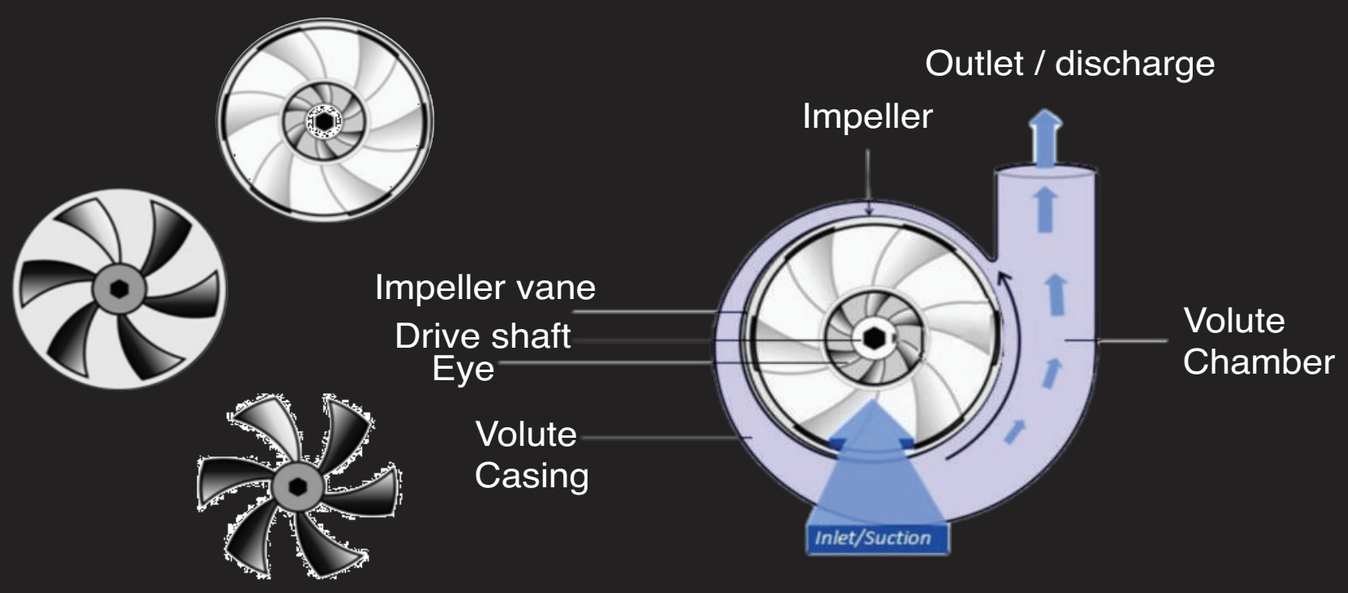
$$2n_2 d\cos(\theta_2) = m\lambda$$

This condition may change after considering possible phase shifts that occur upon reflection

2. Centrifugal pump :

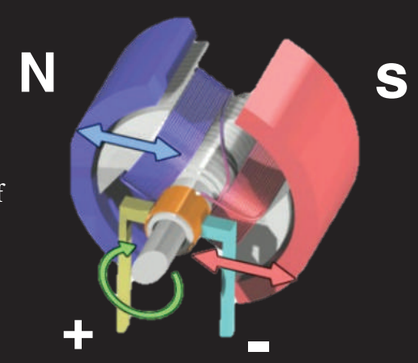
A centrifugal pump is a mechanical device designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers. Fluid enters the rapidly rotating impeller along its axis and is cast out by centrifugal force along its circumference through the impeller's vane tips. The action of the impeller increases the fluid's velocity and pressure and also directs it towards the pump outlet. The pump casing is specially designed to constrict the fluid from the pump inlet, direct it into the impeller and then slow and control the fluid before discharge. Centrifugal pump designs offer simple and low cost solutions to most low pressure, high capacity pumping applications involving low viscosity fluids such as water.

The impeller is the key component of a centrifugal pump. It consists of a series of curved vanes. These are normally sandwiched between two discs (an enclosed impeller). For fluids with entrained solids, an open or semi-open impeller (backed by a single disc) is preferred.



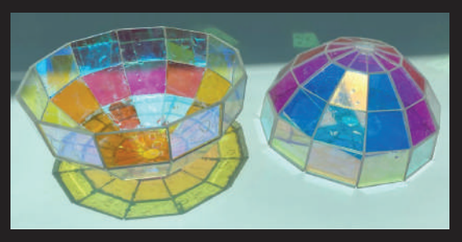
3. Permanent Magnet DC Motor :

A permanent magnet motor operates with magnets creating a fixed magnetic field for the rotor to rotate within. The rotor includes armature coils and commutators mounted on a central axle. When power is applied, current flows through the armature coil, generating a magnetic field that interacts with the magnets, causing rotation. Commutators ensure continuous current flow in the same direction, except for brief moments during rotation when the commutator connections switch. Motor direction is determined by commutator orientation and power supply polarity, allowing for direction reversal by switching positive and negative connections.

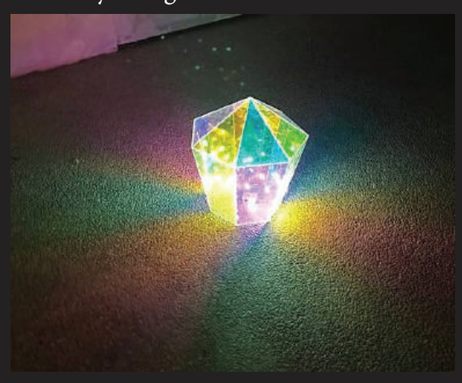


Experimental design :

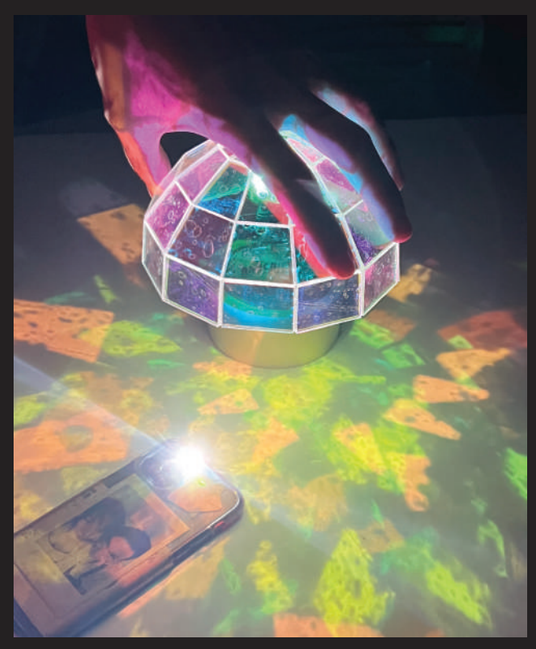
Blue dome light cast test in the dark



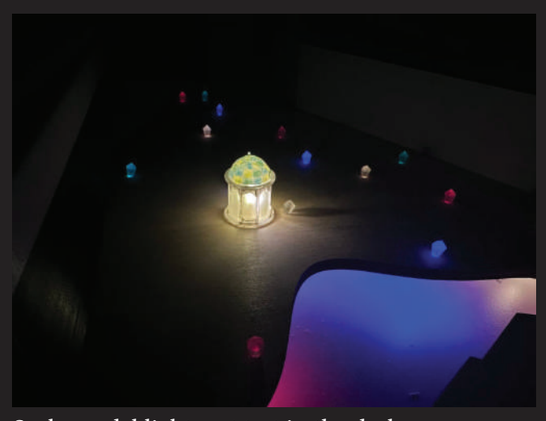
Floor crystal light cast test in the dark



Water experiment test



Blue dome light refraction test in the dark



Scale model light cast test in the dark

Mixed coloured dome light cast test in the dark

Prototype Review:

From the observations we obtained when testing our prototypes, we decided to go with the holographic film and transparent acrylic as the materials for our gazebo in the functional model. In the actual product, we would use transparent polycarbonate and the holographic film material.

Limitations:

As our prototype is of a smaller scale, we cannot fully observe the light patterns that the roof of the actual gazebo will output. We are also unable to see the patterns of the interference of sunlight at different times of the day.

Improvements:

A small camera can be placed under the roof of our gazebo prototype to simulate a person sitting in the gazebo. That way, we can observe a rough estimate of what will be displayed inside the gazebo. The Sun path of the site should be studied more clearly, and a simulation of the Sun's movements can be done to simulate the observations in the gazebo at different times of the day.

References:

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https://courses.lumenlearning.com/suny-physics/chapter/27-7-thin-film-interference/ **(thin film interference)**

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https://en.wikipedia.org/wiki/Permanent_magnet_motor#:~:text=A%20permanent%20magnet%20motor%20generates,loss%20to%20the%20overall%20system **(permanent magnet dc motor)**