1. A boy standing on a stationary lift (open from above) throws a ball upwards with the maximum initial speed he can, equal to 49m s^{-1}. How much time does the ball take to return to his hands? If the lift starts moving up with a uniform speed of 5m s^{-1} and the boy again throws the ball up with the maximum speed he can, how long does the ball take to return to his hands?

2. A bullet of mass 0.012Kg and horizontal speed of 70 ms^{-1} strikes a block of wood of mass 0.4Kg and instantly comes to rest with respect to the block. The block is suspended from the ceiling by means of a thin wire. Find the height to which the block rises.

3. From a uniform disc of radius R, a circular hole of radius $\frac{R}{2}$ is cut out. The centre of the hole is at $\frac{R}{2}$ from the centre of the original disc. Locate the centre of gravity of the resulting flat body.

4. The oxygen molecule has a mass of 5.3×10^{-26} Kg and a moment of inertia of $1.94 \times 10^{-46} Kg\ m^2$ about an axis through its centre, perpendicular to the line joining the two atoms. Suppose the mean speed of such a molecule in a gas is $500 ms^{-1}$ and that its kinetic energy of rotation is two thirds its kinetic energy of translation, find the average angular velocity of the molecule.

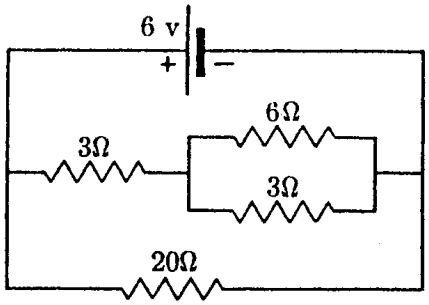
5. A book initially at rest, is pushed along a horizontal table top by a horizontal force of 2N. After one second it has been moved 1.5m. The force of friction is 0.4N. (a) How much work is done on the book by the 2N force? (b) How much work is done on the book by friction? (c) What is the book's kinetic energy after one second? (d) What power is required?

6. An object of mass 0.3Kg undergoes simple harmonic motion at the end of a horizontal spring of spring constant 270 Nm^{-1}. When the object is $4 \times 10^{-2} m$ from its equillibrium position it has a speed of 0.3 ms^{-1}. What is the amplitude of the motion? What is the total energy?

7. A satellite moves in a circular orbit in the Earth's equatorial plane. Seen from the Earth, it appears to be stationary. Find the radius of its orbit. Given $G = 7 \times 10^{-11} Nm^2 Kg^{-2}$ and mass of the Earth=$5.98 \times 10^{24} Kg$.

8. A positively charged pith ball of mass m is suspended by a string, from an infinite plane with a uniform positive charge density σ. The string makes an angle θ with the plane. If T is the tension in the string, find the charge on the ball.

9. Find the currents and potential differences across all resistors in the circuit below. What is the power dissipated in the circuit?



10. A circular loop of radius a lies in the xy-plane and carries a current I. Find the magnetic field $\vec{B}$ at a distance d from the centre of the loop along its axis. Estimate the axial distance d beyond which it may be regarded as a point magnetic dipole at the centre, if the greatest admissible error for $\vec{B}$ is 1%.

11. Three charges q_1, q_2, q_3 are situated at the corners of an equilateral triangle of side a. Find the work required to move the charges to the corners of an equilateral triangle of side $a/2$.

12. The electric field $\vec{E}$ of a monochromatic plane wave is given by $\vec{E} = \vec{E}_0 \cos(k_1 z + k_2 y - \omega t)\hat{i}$ where $E_0 = \frac{2V}{m}$ and $k_1 = k_2 = 10^6/m$. Determine

    (i) the direction of propagation

    (ii) the state of polarization

    (iii) the magnetic field

    (iv) the wavelength and frequency

    (v) Is it in the visible part of the spectrum?

13. The ionization energies of the first three elements H, He, and Li are 13.6 eV, 24.6 eV, and 5.4 eV. Explain qualitatively the change in the ionisation energy from H to Li. Lyman alpha, the $n = 1$ to $n = 2$ transition in atomic hydrogen takes place at 1215Å. Define the wavelength region capable of photoionizing a H atom in the ground state ($n = 1$).

14. It is known that density ρ of air decreases with height h as $\rho = \rho_0 e^{-h/h_0}$ where $\rho_0 = 1.25$ kg m^{-3} is the density at the sea level and h_0 is a constant. Obtain this law assuming that the temperature of atmosphere remains a constant. Also assume that the value of g remains constant.

15. A cylindrical piece of cork of base area A and height h floats in a liquid of density ρ. The cork is depressed slightly and then released. Show that the cork oscillates up and down simple harmonically with a period $T = 2\pi\sqrt{h\rho_c/g\rho}$ where ρ_c is the density of cork. Ignore the damping due to viscosity of the liquid.

16. A small bulb is placed at the bottom of a tank containing water to a depth 80 cm. What is the area of the surface of water through which light from the bulb can emerge out? Refractive index of water is 1.33. Consider the bulb to be a point source.

17. A screen is placed 90 cm from an object. The image of the object on the screen is formed by a convex lens at two different locations separated by 20 cm. What is the focal length of the lens?

18. The 6563 Å H_α line emitted by hydrogen in a star is found to be redshifted by 15 Å. Estimate the speed with which the star is receding from the Earth.

19. Estimate the mean free path and collission frequency of a nitrogen molecule in a cylinder containing nitrogen at 2.0 atm and temperature 17 ^{o}C. Molecular mass of N_2 = 28.0 u and the radius of the nitrogen molecule is $\approx 1\mathring{A}$.

20. What is the reason for operating photodiodes in reverse bias? A p-n photodiode is fabricated from a semiconductor with a band gap of 2.8 eV. Can it detect light of wavelength 6000 nm ?

Useful Data

$h = 6.63 \times 10^{-34} Js$
$1eV = 1.60 \times 10^{-19} J$
$1u = 1.66 \times 10^{-27} Kg$
$1atm = 1.013 \times 10^{5} Pa$
$R = 8.31 J\ mole^{-1}\ K^{-1}$
$N_{Avogadro} = 6.02 \times 10^{23}$