Lab Methods, solutions

Problem 1:
(C) The Hall effect:

Problem 2:
(D) Interactions of elementary particles: Neutrinos only weakly interact, and muons do not interact strongly and are relatively massive.

Problem 3:
(D) The Gaussian distribution: The standard deviation of the Gaussian distribution is given by $\sigma = N_{avg}^{1/2}$. The standard deviation σ is a measure of the width of the distribution. Approximately 1/3 of the counts will lie outside the interval $N_{avg} - \sigma$ to $N_{avg} + \sigma$.

Problem 4:
(D) The Stern-Gerlach Experiment: The deflection is proportional to the vertical component of the electron's magnetic moment, which is proportional to the vertical component of its spin.

Problem 5:
(A) Logic Gates:

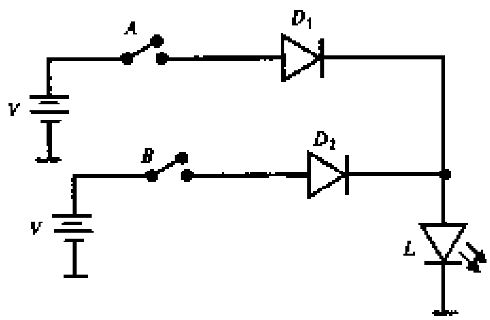


Fig. 7.4 Positive-logic OR gate using diodes.

When either A or B, or both A and B are closed, current will flow from the battery through the diodes to the LED to turn it on. This represents the situations

$A = 0$, $B = 1$, $L = 1$
$A = 1$, $B = 0$, $L = 1$
$A = 1$, $B = 1$, $L = 1$

Problem 6:
(C) Detectors: The solid angle subtended by the detector when the source is located at the center of the face is 2π. So the detector is 100% efficient in detecting gamma rays of the specific energy.
The solid angle subtended by the detector when the detector is moved 1 m away from the source is $\Omega = (\pi d^2/4)/R^2$, where d is the diameter of the detector, R is its perpendicular distance from the source, and d << R. The fraction of gamma rays detected is $\Omega/4\pi$. Here $\Omega/4\pi = (\pi 0.08^2/4) = 4*10^{-4}$.

Problem 7:
(D) Radioactive decay:
$dN = -Ndt/\tau_1 - Ndt/\tau_2 = -Ndt(1/\tau_1 + 1/\tau_2) = -Ndt/\tau_{eff}$. $\tau_{eff} = (\tau_1\tau_2)\,(\tau_1 + \tau_2)$.
Here τ = mean life = $t_{1/2}/\ln 2$.
$t_{1/2eff} = 24*36/(60) = 14.4$

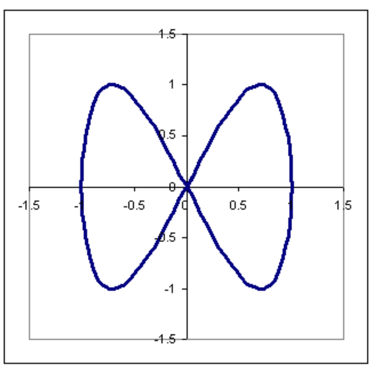
Problem 8:
(A) Counting statistics: The standard deviation is approximately given by $N^{1/2}$.

Problem 9:
(C) Cross section
small beam, big target: (# of particles scattered per second
= [(# of beam particles)/s] × [(# of target particles)/area] × σ
$\sigma = 1/(10^6 * 10^{20}\ \text{cm}^3 * 0.1\ \text{cm}) = 10^{-25}\ \text{cm}^2$.

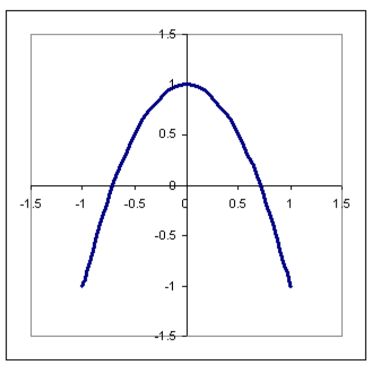
Problem 10:
(C) What did you learn in Electronics Lab?

Problem 11:
(B) Read a log scale!

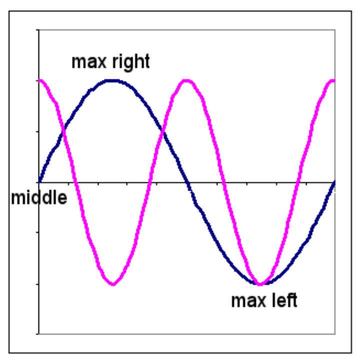
Problem 12:
(A) Plotting Y vs X
$x = \sin(2\pi t)$, $y = \sin(4\pi t + \phi)$



y vs x: $\phi = 0$



y vs x: $\phi = \pi/2$



x, y vs t: $\phi = \pi/2$

Problem 13:
(B) The muons travel with a speed close to the speed of light. It takes them 10 ns to travel from one detector to the other. The resolving time must certainly be smaller than 10 ns.

Problem 14:
(D) Graphing: A log-log plot would be best.

Problem 15: (D)
Oscillations:
Oscillation 1:
period T ~ (1ms/0.5cm)* 6cm, f = 1/T = 83 Hz.
amplitude ~ (4 – 1.5)/2 cm*2 V/cm = 2.5 V.
Oscillation 2:
period T ~ (1ms/0.5cm)* 1cm, f = 1/T = 500 Hz.
amplitude ~ (5 – 3.8)/2 cm*2 V/cm = 1.2 V