Problem 1 -

a) If the work function for a metal is 1.8 eV, what would be the stopping potential for light having a wavelength of 400 nm?

b) What would be the maximum speed of the emitted photoelectrons at the metal’s surface?

Answer: a) 1.3 V b) 680 km/sec.

Problem 2 - An x-ray photon of wavelength 0.01 nm strikes an electron head on ($\phi = 180^\circ$). Determine (a) the change in wavelength of the photon, (b) the change in energy of the photon and (c) the kinetic energy imparted to the electron.

Answers: a) +4.8 pm (b) −41 keV (c) 41 keV

Problem 3 - In 1983 the Infrared Astronomical Satellite (IRAS) detected a cloud of solid particles surrounding the star Vega with the maximum radiated intensity at a wavelength of 32 $\mu$m. What is the temperature of this cloud of particles?

Answer: 91 K

Problem 4 - One cosmic-ray particle approaches the earth along its axis with a velocity of 0.80$c$ toward the North Pole and another, with a velocity of 0.60$c$, toward the South Pole. What is the relative speed of approach of one particle with respect to the other?

Answer: $|v| = 0.946c$

Problem 5 - A spaceship of rest length 130 m drifts past a timing station at a speed of 0.74$c$. (a) What is the length of the spaceship as measured by the timing station? (b) What time interval between the passage of the front and back end of the ship will the station monitor record?

Answer: (a) 87.4 m (b) 394 ns

Problem 6 - A pion is created in the higher reaches of the earth’s atmosphere when an incoming high-energy cosmic-ray particle collides with an atomic nucleus. A pion so formed descends toward earth with a speed of 0.99$c$. In a reference frame in which they are at rest, pions decay with a mean life of 26 ns. As measured in a frame fixed with respect to the earth, how far (on the average) will such a typical pion move through the atmosphere before it decays?

Answer: 54.7 m

Problem 7 - A spaceship is receding from the earth at a speed of 0.20$c$. A light on the rear of the ship appears blue ($\lambda = 450$ nm) to passengers on the ship. What color would it appear to an observer on earth?

Answer: 551 nm

Problem 8 - A $K^0$ particle with rest energy 497.7 MeV decays at rest into a $\pi^+$ and $\pi^-$ each with rest energy of 139.6 MeV. Find the kinetic energies and momenta of the $\pi^+$ and $\pi^-$. 
Answer: $K = 109.3$ MeV, $p = 206$ MeV/c

**Problem 9** - A nonrelativistic particle is moving three times as fast as an electron. The ratio of their de Broglie wavelengths, particle to electron, is $1.813 \times 10^{-4}$. By calculating its mass, identify the particle.

Answer: a neutron $(m_c^2 = 939.6$ MeV$)$

**Problem 10** - An (a) proton or (b) electron is trapped in a one-dimensional box of 100 pm in length. What is the minimum energy these particles can have?

Answer: (a) 20.5 meV (b) 37.7 eV

**Problem 11** - A particle is trapped in an infinite one-dimensional well of width $L$. If the particle is in its ground state, evaluate the probability to find the particle between $x = L/3$ and $x = 2L/3$. Use the integral:

$$
\int \sin^2 u \, du = \left[ \frac{u}{2} - \frac{1}{4} \sin 2u \right]
$$

Answer: 0.6090

**Problem 12** - Find the de Broglie wavelength of (a) a nitrogen molecule $(m = 28 \mu)$ in air at room temperature (note: $K = (3/2)kT$), (b) A 5-MeV proton (c) A 50-GeV electron (d) An electron moving at $v = 10^6$ m/s.

Answers: (a) 0.0279 nm, (b) 13 fm, (c) 0.025 fm, (d) 0.73 nm