1. (a) State the Biot-Savart law for computing the magnetic field $\vec{B}(\vec{r})$, define all your terms.

(b) Consider a segment of a wire, carrying a current $I$, located along the $x$-axis from $x = -a$ to $x = a$. Compute the magnetic field at a point $\vec{r}$ defined by the Cartesian coordinates $(x, y, z) = (0, D, 0)$, with $D > 0$. A correct expression would take the form of a one-dimensional integral with all terms defined. Do **not** evaluate the integral.
2. Consider a square loop of wire, of side \( w \), carrying a current \( I \).

(a) Determine the magnetic dipole moment \( \vec{m} \) of the loop.

(b) Determine the approximate magnetic field a distance \( z \gg w \) above the center of the square, \( O \).

(c) Determine the magnetic field at the center of the square, \( O \).
3. An infinitely long circular cylinder of radius $R$ carries a magnetization $\vec{M} = ks^2 \hat{\phi}$, where $k$ is a constant, $s$ is the distance from the axis and $\hat{\phi}$ is the azimuthal unit vector.

(a) Consider the vector potential $\mathbf{A}$ for the given situation. Is the vector potential expressed as a volume integral, a surface integral, or a sum of a volume integral and a surface integral? Explain.

(b) Determine the bound current density, $\mathbf{J}_b$.

(c) Determine the total bound current, and then define this quantity to be $I_b$.

(d) Determine the magnetic field $\mathbf{B}$ outside the cylinder.

(e) Determine the magnetic field $\mathbf{B}$ and $\mathbf{H}$ inside the cylinder.