Problem 1: Griffiths 5.8  A square loop of wire (side $a$) lies on a table, a distance $s$ from a very long straight wire, which carries a current $I$.
(a) Find the flux of $B$ through the loop.
(b) If someone now pulls the loop directly away from the wire, at speed $v$, what emf is generated? In what direction does the current flow?
(c) What if the loop is pulled to the right at speed $v$, instead of away?

Problem 2: Griffiths 5.19  A toroidal coil has a rectangular cross section, with inner radius $a$, outer radius $a + w$, and height $h$. It carries a total of $N$ tightly wound turns, and the current is increasing at a constant rate ($\frac{dI}{dt} = k$). If $w$ and $h$ are both much less than $a$, find the electric field at a point $z$ above the center of the toroid.

Problem 3: Griffiths 5.28  A long cable carries current in one direction uniformly distributed over its (circular) cross section. The current returns along the surface (there is a very thin insulating sheath separating the currents). Find the self-inductance per unit length.

Problem 4: Griffiths 6.30  Two tiny wire loops, with areas $a_1$ and $a_2$, are situated a displacement $r$ apart.
(a) Find their mutual inductance.
(b) Suppose a current $I_1$ is flowing in loop 1, and we propose to turn on a current $I_2$ in loop 2. How much work must be done, against the mutually induced emf, to keep the current $I_1$ flowing in loop 1?

Problem 5: Griffiths 6.53  Two coils are wrapped around a cylindrical form in such a way that the same flux passes through every turn of both coils. The “primary” coil has $N_1$ turns and the secondary has $N_2$. If the current $I$ in the primary is changing, find the ratio of the emf of the secondary to the primary.

Problem 6: Griffiths 6.54  A transformer takes an input AC voltage of amplitude $V_1$, and delivers an output voltage of amplitude $V_2$, which is determined by the turns ratio. If $N_2 > N_1$ the output voltage is greater than the input voltage. Why doesn’t this violate conservation of energy?
(a) In an ideal transformer the same flux passes through all turns of the primary and of the secondary. Show that in this case $M^2 = L_1 L_2$, where $M$ is the mutual inductance of the coils, and $L_1, L_2$ are their individual self-inductances.
(b) Suppose the primary is driven with AC voltage $V_{in} = V_1 \cos(\omega t)$, and the secondary is connected to a resistor, $R$. Show that the two currents satisfy the relations
$$L_1 \frac{dI_1}{dt} + M \frac{dI_2}{dt} = V_1 \cos(\omega t); \quad L_2 \frac{dI_2}{dt} + M \frac{dI_1}{dt} = -I_2 R$$
(c) Using the result in (a), solve these equations for $I_1(t)$ and $I_2(t)$. (Assume $I_1$ has no DC component.)
(d) Show that the output voltage ($V_{out} = I_2 R$) divided by the input voltage ($V_{in}$) is equal to the turns ratio: $\frac{V_{out}}{V_{in}} = \frac{N_2}{N_1}$