Magnetic Pressure and Force

Take a look at the Refrigerator Magnet Document. In the middle of page 2, there is an expression for the force that looks like

$$F_{attractive} = \frac{B_{mag}{}^2}{2m_o} wd\left(\frac{w}{2T} + 1\right)$$

This expression is the product of the magnetic field energy density at the contact surfaces times the area of the surfaces. Let us look at each contact surface separately. First, the magnetic field in the magnet and therefore just under the magnet is equal to B_{mag}. The energy density in the magnet is given by $\frac{B_{mag}{}^2}{2m}$ and the energy density just outside of the magnet is $\frac{B_{mag}{}^2}{2m_o}$. The difference between the two is the pressure on the surface of the magnet. Since the first expression is much, much smaller than the second, we only need to use the second term, not their difference. The area of the magnet is wd, therefore the force due to the magnet is $\frac{B_{mag}{}^2}{2m_o} wd$. The main force actually comes from the locations where the plate around the magnet contacts the refrigerator door. These plates have a contact area equal to 2Td, since there are two contact surfaces. The magnetic field at this surface is equal to B_{plate} which is larger than the field in the magnet by the ratio w/2T or $B_{plate} = \frac{w}{2T} B_{mag}$. The force on the surface is, therefore, equal to

$$F_{attractive} = \frac{\left(\frac{w}{2T} B_{mag}\right)^2}{2m_o} 2Td = \frac{w^2 d}{4Tm_o} B_{mag}{}^2$$

The sum of these two terms is

$$F_{attractive} = \frac{B_{mag}{}^2}{2m_o}\left(\frac{w^2 d}{2T} + wd\right)$$

which simplifies to the first expression above.

The key thing to learn from this is that the force can be easily determined by evaluating the magnetic energy density at the surface of magnet (either permanent or electromagnet) and multiplying it by the area through which the flux passes, or, equivalently, the area where the force acts.