Ch.14 Prob. 31

coil $N_c = 40$ turns

$A = 7.5 \times 10^{-3}\ m^2$

solenoid $\ell = 0.50\ m$

$N_s = 500$ turns

a) Find the mutual inductance.

$\Phi_{21} = A B_1$

for a solenoid $B_1 = \dfrac{\mu_0 N_1 I_1}{\ell}$

so $\Phi_{21} = \dfrac{A \mu_0 N_1 I_1}{\ell}$

$$M = \frac{N_2 \Phi_{21}}{I_1} = \frac{N_2 A \mu_0 N_1 I_1}{I_1 \ell} = \frac{\mu_0 A N_1 N_2}{\ell}$$

$$= \frac{4\pi \times 10^{-7}\ \frac{T \cdot m}{A}\,(7.5 \times 10^{-3}\ m^2)(500)(40)}{(0.50\ m)} = 3.77 \times 10^{-4}\ \frac{T \cdot m}{A} = 3.77 \times 10^{-4}\ H$$

b) Outer coil now has 3x the radius. What is the mutual inductance now?

It is the same. All of the magnetic flux is contained inside the solenoid. It isn't changing, so the mutual inductance doesn't either.

$M = 3.77 \times 10^{-4}\ H$