1. Use J & C table 6-3 and/or table A-5 to solve the following:

a. What fluence of 20 MeV electrons will deliver 1 Gy of dose to the first 1 mm of a water phantom?

Energy deposited is equal to the electron fluence multiplied by the collisional stopping power multiplied by the thickness.

\[
1 \text{ Gy} = 1 \frac{\text{J}}{\text{kg}} \cdot \frac{1}{1.6 \times 10^{-16}} \frac{\text{MeV}}{\text{J}} \cdot 10^{-3} \frac{\text{kg}}{\text{g}} = 6.25 \times 10^9 \frac{\text{MeV}}{\text{g}}
\]

So the energy deposited in the phantom is given by

\[
6.25 \times 10^9 \frac{\text{MeV}}{\text{g}} \cdot 0.1 \text{ cm} \cdot 1 \frac{\text{g}}{\text{cm}^3} = 6.25 \times 10^8 \frac{\text{MeV}}{\text{cm}^2}
\]

From Table A-5, the mass collisional stopping power for 20 MeV electrons in water is 2.063 MeV cm\(^{-2}\) g\(^{-1}\). Multiplying this by the density to obtain the collisional stopping power gives us a 2.063 MeV cm\(^{-1}\).

So,

\[
6.25 \times 10^8 \frac{\text{MeV}}{\text{cm}^2} = \varphi \cdot 2.063 \frac{\text{MeV}}{\text{cm}} \cdot 0.1 \text{ cm}
\]

\[
\varphi = \frac{6.25 \times 10^8 \frac{\text{MeV}}{\text{cm}^2}}{2.063 \cdot 0.1 \frac{\text{cm}}{\text{MeV}} \cdot \frac{1}{\text{cm}}}
\]

\[
= 3.03 \times 10^9 \frac{\text{cm}^{-2}}{}
\]

b. What fluence would be needed if 500 keV electrons were used?

If 500 keV electrons were used, the mass collisional stopping power would be 2.033 MeV cm\(^{-2}\) g\(^{-1}\). Multiplying this by the density to obtain the collisional stopping power gives us a 2.033 MeV cm\(^{-1}\). The fluence would then be given by

\[
\varphi = \frac{6.25 \times 10^8 \frac{\text{MeV}}{\text{cm}^2}}{2.033 \cdot 0.1 \frac{\text{cm}}{\text{MeV}} \cdot \frac{1}{\text{cm}}}
\]

\[
= 3.07 \times 10^9 \frac{\text{cm}^{-2}}{}
\]

c. What fluence of 20 MeV electrons will deliver 1 Gy of dose to the first 1 mm of an aluminum phantom?
The density of aluminum is 2.699 g cm\(^{-3}\), so 1 Gy dose deposited in 1 mm of phantom corresponds to an energy of

\[
6.25 \times 10^9 \frac{\text{MeV}}{\text{g}} \cdot 0.1 \text{ cm} \cdot 2.699 \frac{\text{g}}{\text{cm}^3} = 1.687 \times 10^8 \frac{\text{MeV}}{\text{cm}^2}
\]

The mass collisional stopping power for 20 MeV electrons in aluminum is 1.699 MeV cm\(^{-2}\) g\(^{-1}\). Multiplying this by the density to obtain the collisional stopping power gives us a 4.586 MeV cm\(^{-1}\).

The electron fluence is then given as

\[
\varphi = \frac{1.687 \times 10^9 \text{ MeV cm}^1}{4.586 \cdot 0.1 \text{ cm}^2 \text{ MeV cm}} = 3.68 \times 10^9 \text{ cm}^{-2}
\]

d. By how much would the answer change if the question asked for the dose delivered in the first 0.1 mm of phantom?

The phantom depth appears in the equation for energy deposition and the equation for electron fluence, so it cancels out. There would be a negligible change because in the previous part of the question, there might be a small decrease in electron energy as the beam passes through the aluminum thus decreasing slightly the stopping power. This decrease can be neglected, however.