Let’s assume you have measured the following measurements (see fig. 9-2 of procedure for torque notation):

Left hand side of fulcrum - mass = (masses + hanger) = (0.2000 + 0.0166) kg = 0.21666 kg
distance from fulcrum = 35.6 cm = 0.356 m

Right hand side of fulcrum - (masses + hanger) = (0.3000 + 0.0165) kg = 0.31665 kg
distance from fulcrum = 24.4 cm = 0.244 m

These measurements yield the following torques, respectively;

\[ \tau_{cc} = (0.21666 \text{ kg} \times 9.8000 \text{ m/s}^2 \times 0.356 \text{ m}) = 0.75588 \text{ N-m} \]
\[ \tau_c = -(0.31665 \text{ kg} \times 9.8000 \text{ m/s}^2 \times 0.244 \text{ m}) = -0.75717 \text{ N-m} \]

We must now determine the uncertainty of the torque using the following uncertainties:

We are using a meter stick with a readability of 1 mm and an uncertainty- \( \delta r = 0.5 \text{ mm} = 0.05 \text{ cm} \)

However, since there are two clamps there is an uncertainty associated with both and thus we will use an uncertainty of \( \delta r = \sqrt{0.05^2 + 0.05^2} \text{ cm} = \sqrt{2} \times 0.05 \text{ cm} = 0.07 \text{ cm} \)

| Uncertainty of r use 0.07 cm | For the mass uncertainty we will use 1 g |

(Please note that this value for mass uncertainty is an approximate method only and there are several different ways to achieve a more precise value, e.g., using a balance to measure individual masses or by using a statistically determined mass uncertainty)

Since torque is defined as force times distance (i.e., \( \tau = F \times d \)) you must use uncertainty of multiplied quantities (see appendix – pages A-6 through A-10). Thus we see

\[ \frac{\delta \tau}{\tau} = \sqrt{\left( \frac{\delta F}{F} \right)^2 + \left( \frac{\delta r}{r} \right)^2} = \sqrt{\left( \frac{\delta (mg)}{mg} \right)^2 + \left( \frac{\delta r}{r} \right)^2} \]

Since force (weight) is mg and g is a constant, we see

\[ \frac{\delta \tau}{\tau} = \sqrt{\left( \frac{\delta (mg)}{mg} \right)^2 + \left( \frac{\delta r}{r} \right)^2} = \sqrt{\left( \frac{\delta m}{m} \right)^2 + \left( \frac{\delta r}{r} \right)^2} \]. \[ \Rightarrow \frac{\delta \tau}{\tau} = \sqrt{\left( \frac{\delta m}{m} \right)^2 + \left( \frac{\delta r}{r} \right)^2} \quad \text{Eq-1} \]

Please note the equation 1 above is simply another way of saying that the fractional uncertainty of quantities that are multiplied together is obtained by first converting uncertainties to a fraction (or percent) and then adding those uncertainties (in this case we are adding in quadrature).
Examining the measured values above, we see for counterclockwise values;

\[
\frac{\delta\tau_{cc}}{\tau_{cc}} = \sqrt{\left(\frac{\delta m_{cc}}{m_{cc}}\right)^2 + \left(\frac{\delta r_{cc}}{r_{cc}}\right)^2} \Rightarrow \frac{\delta\tau_{cc}}{0.75588 \text{ N-m}} = \sqrt{\left(\frac{\delta(1g)}{216.66g}\right)^2 + \left(\frac{\delta(0.07cm)}{35.6cm}\right)^2}
\]

\[
\delta\tau_{cc} = 0.75588 \text{ N-m} \times \sqrt{0.0046155^2 + 0.0019663^2} = 0.75588 \text{ N-m} \times 0.0050169 = 0.003792 \text{ N-m}
\]

Rounding the uncertainty to one significant figure we see

\[
\delta\tau_{cc} = 0.004 \text{ N-m}.
\]

We can thus write counter clockwise torque sum and its uncertainty (i.e., \(\tau_{cc} \pm \delta\tau_{cc}\)) as

\[
(0.75588 \pm 0.004)\text{ N-m} = (0.756 \pm 0.004)\text{ N-m}
\]

Repeating the process above for the clockwise torque we see

\[
\frac{\delta\tau_c}{0.75717 \text{ N-m}} = \sqrt{\left(\frac{\delta(1g)}{316.65g}\right)^2 + \left(\frac{\delta(0.07cm)}{24.4cm}\right)^2}
\]

which yields

\[
\delta\tau_c = 0.0032305 \text{ N-m} = 0.003 \text{ N-m}.
\]

We can thus write clockwise torque sum and its uncertainty (i.e., \(\tau_c \pm \delta\tau_c\)) as

\[
(-0.757178 \pm 0.003)\text{ N-m} = (-0.757 \pm 0.003)\text{ N-m}
\]

The sum of the torques including uncertainties is given by

\[
\Sigma\tau = (0.756 \pm 0.004)\text{ N-m} + (-0.757 \pm 0.003)\text{ N-m}
\]

Please note that the uncertainties should be added in quadrature to yield final answer

\[
\Sigma\tau = \left(-0.001 \pm \sqrt{0.004^2 + 0.003^2}\right)\text{ N-m} = (-0.001 \pm 0.005)\text{ N-m} = \]