A-Level Mathematics S1: Normal Distribution with a TI-83/TI-83+ Calculator

All functions can be found under the DISTR menu, which can be accessed using 2nd+VARS. The normal distribution is completely defined by a mean and standard deviation, and there are four possible varibles exam questions will ask for:

- Mean (μ)
- Standard deviation (σ) or variance (σ^2)
- A given value or values of the variable
- A probability or proportion

Drawing a graph and labelling it is always a good place to start.

1 normalcdf - looking up a percentage from a z value

$$\text{normalcdf}(\text{lower bound}, \text{upper bound}, \mu, \sigma)$$

This function will let you look up values in the standard normal distribution table more quickly and with more accuracy because

$$\Phi(z) = \text{normalcdf}(-1\text{E}99, z, 0, 1)$$

This works because the tables is based off a normal distribution with a mean of zero, at the origin, and with a standard deviation of one. -1E99 represents the smallest number the calculator can deal with, that is -1×10^{99} in standard form. So it is looking up the probability that the random variable Z is less

than the x-axis value z. Normally (haha) you would convert values to their standardised score in order to use the table. However, with your calculator you can take a shortcut by changing the mean and standard deviation input. This is good for checking your answers. For example, the mass of boiled sweets has a mean of 10g with a standard deviation of 2g, and is normally distributed. What percentage of sweets will have a mass of less than 8g, but greater than 5g?

$$
\begin{aligned}
M &\sim \mathrm{N}\left(10, 2^2\right) \\
\mathrm{P}(5 < M < 8) &= \Phi\left(\frac{8-10}{2}\right) - \Phi\left(\frac{5-10}{2}\right) \\
&= \Phi(-1) - \Phi(-2.5) \\
&= (1 - \Phi(1)) - (1 - \Phi(2.5)) \\
&= .1587 - .0062 = .1525 \\
&\Rightarrow 15.3\%
\end{aligned}
$$

or, with a calculator,

$$
\begin{aligned}
\mathrm{P}(5 < M < 8) &= \text{normalcdf}(5, 8, 10, 2) = .1524455797... \\
&\Rightarrow 15.3\%
\end{aligned}
$$

Despite questionable rounding from the point of view of the AS/A2 table, clearly the calculator has provided a shortcut to the answer, and thus provides a valuable method of checking working at the end of a question.

2 invNorm - working backwards, from probability to z value

Continuing the previous example, the company aim that 93% of the sweets produced will be below a certain tolerance level in mass, before they start losing the company money. Find this mass. Manually you might use the percentage points table but I prefer the standard, normal table (I'm hilarious)

for this situation:

$$\begin{aligned}
\Phi(z) &\approx .93 \\
z &\approx 1.48 \\
1.48 &= \frac{x-10}{2} \\
\Rightarrow x &= 12.96 \\
x &\approx 13.0\text{g} \\
\text{or, with a calculator,} & \\
\text{invNorm}(.93, 10, 2) &= 12.95158206...\% \\
\Rightarrow x &\approx 13.0\text{g}
\end{aligned}$$

Again there is some questionable rounding going on somewhere, but you get the point.

3 Key points

- $\Phi(z) = \text{normalcdf}(-1\text{E}99, z, 0, 1)$
- $\text{P}(a < X < b) = \text{normalcdf}(a, b, \mu, \sigma)$
- $z = \text{invNorm}(\Phi(z), \mu, \sigma)$
- $z = \text{invNorm}(1 - p, \mu, \sigma)$

Your calculator has other normal distribution capabilities. See if you can work them out.