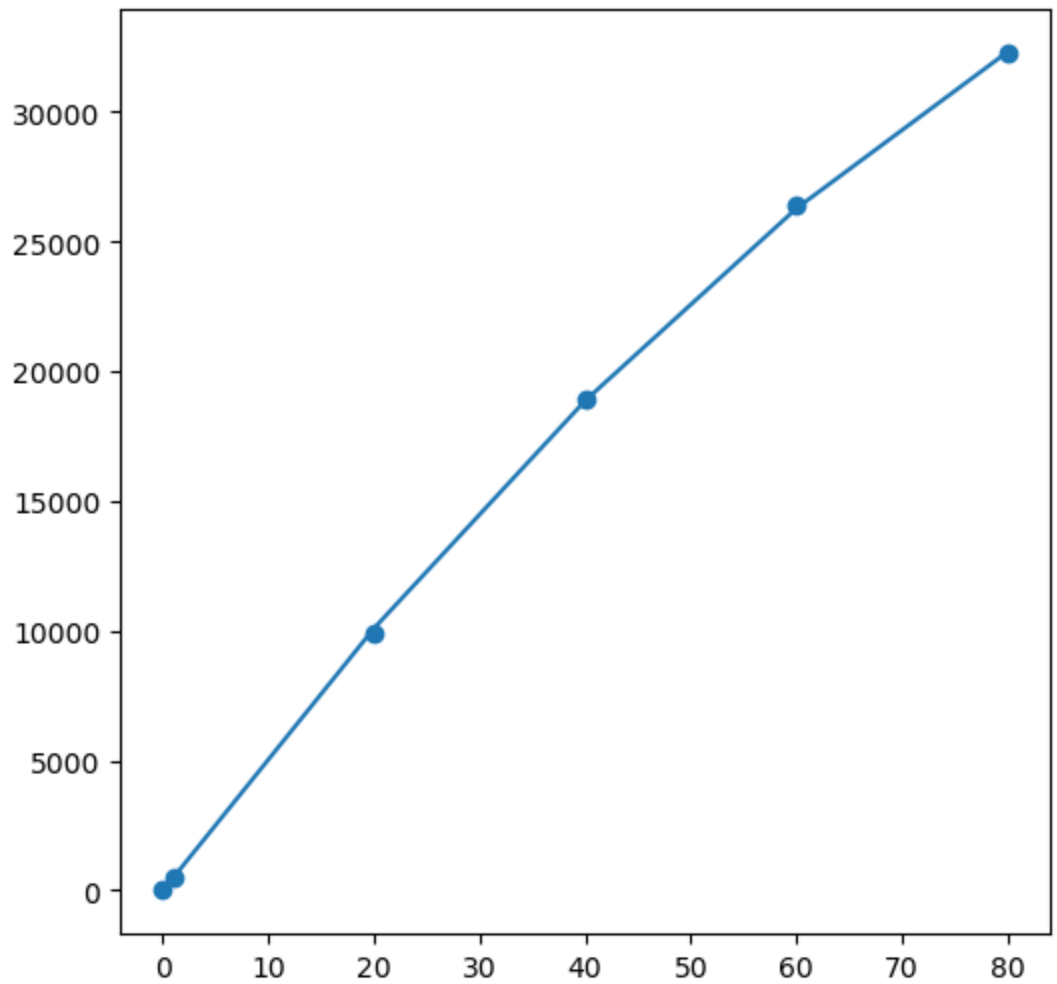
9.1

In [2]:
```
## %matplotlib inline

import numpy as np
import matplotlib.pyplot as plt

exptime = np.array([0., 1., 20., 40., 60., 80.])
DN = np.array([0., 500., 9878., 18955., 26390., 32267.])

fig = plt.figure(figsize=(10, 10))

fig = plt.figure(figsize=(6,6))
ax = fig.add_subplot(111)

ax.scatter(exptime, DN)
coeffs = np.polyfit(exptime, DN, 2)
print("c, b, a: ")
print(coeffs)

ax.plot(exptime, np.polyval(coeffs, exptime))
```

```
c, b, a:
[ -1.71368271 542.06834791 -66.63862759]
```

Out[2]:
```
[<matplotlib.lines.Line2D at 0x1254a7380>]
```

```
<Figure size 1000x1000 with 0 Axes>
```



9.2

We're given a magnitude difference between two stars, but all of the thinking we have in this chapter involves fluxes. So the first thing we need to do is convert the magnitude difference Δm into a relationship in terms of (incorrect) fluxes, F_1' and F_2' -- "incorrect" because they are impacted by the uncorrected non-linear response.

$$\Delta m' = -2.5 \log_{10}\left(\frac{F_1'}{F_2'}\right) \Rightarrow \frac{F_2'}{F_1'} = 10^{\Delta m/2.5} = 10^{1.25/2.5} = 3,$$

meaning star 2 is *measured* to be 3 times brighter than star 1, but because of the non-linearity of our detector, the apparent flux for star 2 is incorrectly estimated.

We're told that star 2 produced a DN value of 30000, meaning star 1 produced a DN value of 10000.

If $F_{1/2}$ is the *corrected* relative flux for star 1/2, then the corresponding output, i.e., data number $\mathrm{DN}_{1/2}$ is given by Equation 9.23:

$$\mathrm{DN}_{1/2} = a + b\left(F_{1/2}At\right) + c\left(F_{1/2}At\right)^2,$$

where A is the telescope area and t is the exposure time (and we're assuming they are both the same for both stars are the same, as indicated).

We can use the quadratic equation to calculate $F_{1/2}At$:

$$F_{1/2}t = \frac{-b \pm \sqrt{b^2 - 4\left(a - \mathrm{DN}_{1/2}\right)c}}{2c}.$$

For star 2, we have

$$F_2 t = \frac{-540 \pm \sqrt{(540)^2 - 4\,(-67 - 30000)\,(-1.7)}}{2\,(-1.7)} = 247 \text{ or } 71.$$

For star 1,

$$F_1 t = \frac{-540 \pm \sqrt{(540)^2 - 4\,(-67 - 10000)\,(-1.7)}}{2\,(-1.7)} = 300 \text{ or } 21.$$

Using the flux values that are closest to one another means we are assuming (reasonably) that the non-linear effects are small. So

$$\frac{F_2}{F_1} = \frac{71}{21} \approx 3.4.$$

In any case, we can now estimate the correct relative magnitudes:

$$\Delta m = -2.5\log_{10}\left(\frac{F_1}{F_2}\right) = -2.5\log_{10}(1/3.4) \approx \boxed{1.3}.$$