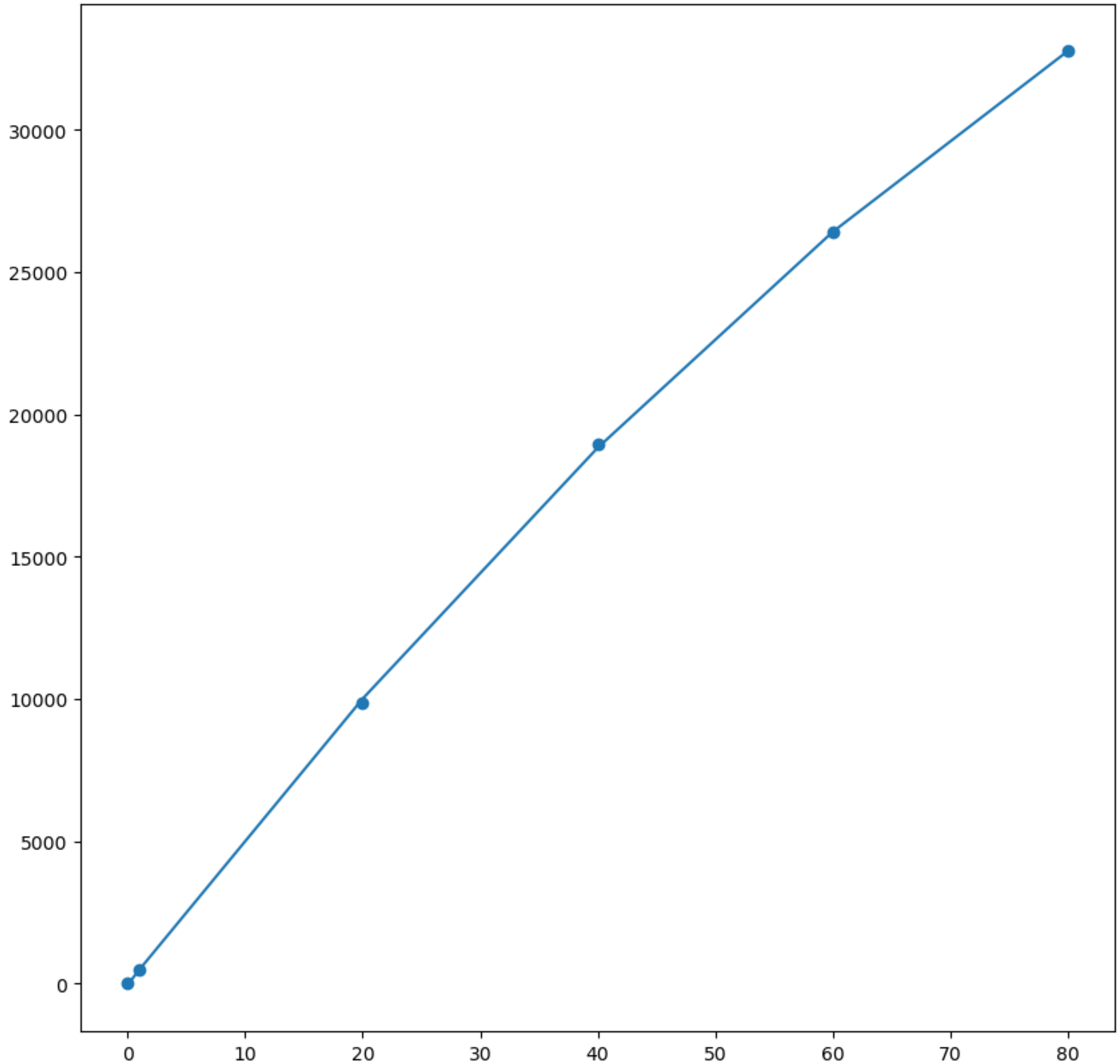
9.1

In [4]:
```
## %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., 32767.])

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

plt.scatter(exptime, DN)
coeffs = np.polyfit(exptime, DN, 2)
print("c, b, a: ")
print(coeffs)
plt.plot(exptime, np.polyval(coeffs, exptime))
```

```
c, b, a:
[ -1.5411054  533.44373307 -39.56407026]
```

Out[4]:
```
[<matplotlib.lines.Line2D at 0x7fb3e9b75760>]
```



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:

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

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

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

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

For star 2, we have

$$F_2t = \frac{-533 \pm \sqrt{(533)^2 - 4\left(-39.6 - 30000\right)\left(-1.54\right)}}{2\left(-1.54\right)} = 275 \text{ or } 70.9.$$

For star 1,

$$F_1t = \frac{-533 \pm \sqrt{(533)^2 - 4\left(-39.6 - 10000\right)\left(-1.54\right)}}{2\left(-1.54\right)} = 326 \text{ or } 20.1.$$

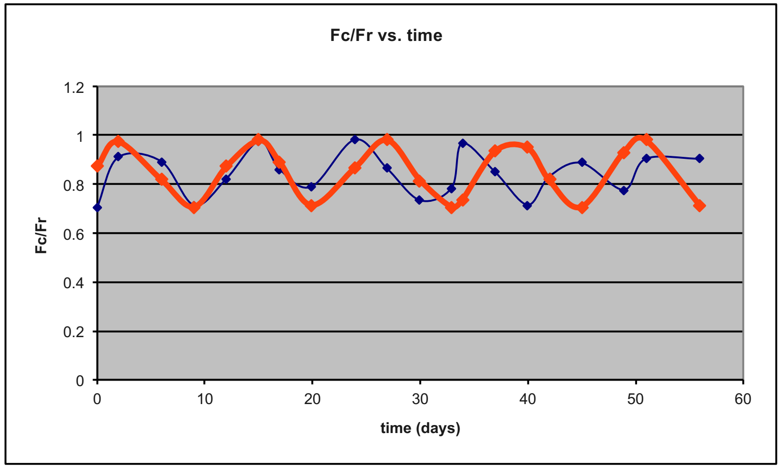
Using the flux values that are closest to one another means we are assuming (reasonably) that the non-linear effects are small. So

$$\frac{F_2}{F_1} = \frac{70.9}{20.1} \approx 3.5.$$

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

$$\Delta m = -2.5\log_{10}\left(\frac{F_1}{F_2}\right) = -2.5\log_{10}(1/3.5) \approx \boxed{1.36}.$$

Day and hour when the photograph was taken	Interval time (days)	Flux of the Cepheid Fc	Flux of the Reference Star Fr	Fc / Fr	Approximation	
99-10-24-03-23-25	0	0.423832	0.599292	0.707221188	0.872564982	0.02733857
99-10-26-01-41-23	1.929	0.546565	0.600679	0.90991195	0.97410854	0.0041212
99-10-30-02-07-12	5.947	0.533053	0.596949	0.89296238	0.818580984	0.00553259
99-11-02-03-17-50	8.996	0.42808	0.599529	0.714027178	0.70775696	3.9316E-05
99-11-05-03-11-00	11.991	0.488083	0.593231	0.8227537	0.871951262	0.0024204
99-11-08-04-07-00	15.030	0.576292	0.59072	0.975575569	0.979079957	1.2281E-05
99-11-10-01-42-37	16.930	0.503473	0.584763	0.860986417	0.891421071	0.00092627
99-11-13-00-40-34	19.887	0.459633	0.581997	0.789751494	0.71435015	0.00568536
99-11-17-01-22-04	23.916	0.570029	0.580129	0.982590079	0.86654369	0.01346676
99-11-20-01-19-30	26.914	0.49642	0.574385	0.864263517	0.98071759	0.01356155
99-11-23-02-55-34	29.981	0.425801	0.579966	0.734182693	0.816182346	0.00672394
99-11-26-01-22-41	32.916	0.45835	0.583682	0.785273488	0.706678793	0.00617713
99-11-27-00-48-33	33.892	0.572595	0.591732	0.967659346	0.735390905	0.05394863
99-11-30-03-15-26	36.994	0.500974	0.590887	0.84783385	0.936330597	0.00783167
99-12-03-02-39-09	39.969	0.429432	0.599937	0.715795158	0.948394188	0.05410231
99-12-05-02-44-18	41.973	0.494614	0.595219	0.830978178	0.816740359	0.00020272
99-12-08-02-25-59	44.960	0.537095	0.605438	0.887118086	0.70724187	0.03235545
99-12-12-01-10-52	48.908	0.466865	0.600912	0.776927404	0.931549467	0.02390798
99-12-14-02-08-45	50.948	0.532273	0.588834	0.903944066	0.980288581	0.00582849
99-12-19-03-23-16	56.000	0.532273	0.588834	0.903944066	0.711580742	0.03700365
				0.84368499		0.30118627



Approximation function :	f(t) = A*sin(omega*t + phi) + B
Variable A =	0.138905089
Variable omega = 2PI/T =	0.523598776
Variable phi =	0.20943951
Variable B =	0.84368499

chi^2	0.301186273

Pulsation Period T (days) =	**11.99391651**

Flow Fr of the comparison star you chose =	1.30E-14
Average flow of the Cepheid (W.m-2) =	**1.10E-14**

Luminosity of the Cepheid/Luminosity of the Sun =	8000
Luminosity of the Sun Ls (W)=	3.85E+26
Luminosity of the Cepheid Lc (W) =	**3.08E+30**

Distance to the Sun (m) =	**4.72845E+21**
In lightyears =	**5.00E+05**