This is the definition of the force of mortality for the G82M table.

```
>  m := t ->
  0.0005+0.00007585775*10^(0.038*t) ;
```

$$m := t \rightarrow 0.0005 + 0.00007585775\ 10^{(0.038\ t)}$$

This is the survival function for a life aged 30

```
> evalf(0.00007585775*10^(0.038*30)/(0.038*ln
  (10)));
```

$$0.01196742383$$

```
> p := t ->
  exp(-0.0005*t-0.01196742383*(10^(0.038*t)-1
  ));
```

$$p := t \rightarrow \mathbf{e}^{(-0.0005\ t - 0.01196742383\ (10^{(0.038\ t)} - 1))}$$

This is a continuous 30 year annuity for a life aged 30.

```
> evalf( Int( exp(-0.05*t)*p(t), t=0..30 ));
```

$$14.99247514$$

The endowment assurance is

```
> evalf(1-0.05*14.99247514);
```

$$0.2503762430$$

The premium is

```
> evalf(.2503762430/14.99247514);
```

$$0.01670012727$$

Thiele's equation

```
> deq1  := diff(v(t),t) - (0.05+m(30+t))*v(t) - .1670012727e-1 + m(30+t)= 0;
```

$$deq1 := \left(\frac{d}{dt}\mathrm{v}(t)\right) - (0.0505 + 0.00007585775\ 10^{(1.140 + 0.038\ t)})\ \mathrm{v}(t) - 0.01620012727 + 0.00007585775\ 10^{(1.140 + 0.038\ t)} = 0$$

```
> tc1   := v(30) = 1;
```

$$tc1 := \mathrm{v}(30) = 1$$

```
> dsol1 := dsolve({deq1,tc1}, numeric, range=0..30);
```

$$dsol1 := \mathbf{proc}(x\_rkf45)\ \ldots\ \mathbf{end\ proc}$$

```
> dsol1(0);
```

$$[t = 0.,\ \mathrm{v}(t) = -0.57202203161688114\ 10^{-7}]$$

```
> dsol1(5);
```

$$[t = 5.,\ \mathrm{v}(t) = 0.0850542441844581165]$$

```
> dsol1(10);
```

$$[t = 10.,\ \mathrm{v}(t) = 0.191746596617043186]$$

```
> dsol1(20);
```

$$[t = 20.,\ \mathrm{v}(t) = 0.495288131004382626]$$

```
> dsol1(25);
```

$$[t = 25.,\ \mathrm{v}(t) = 0.712772498634511531]$$

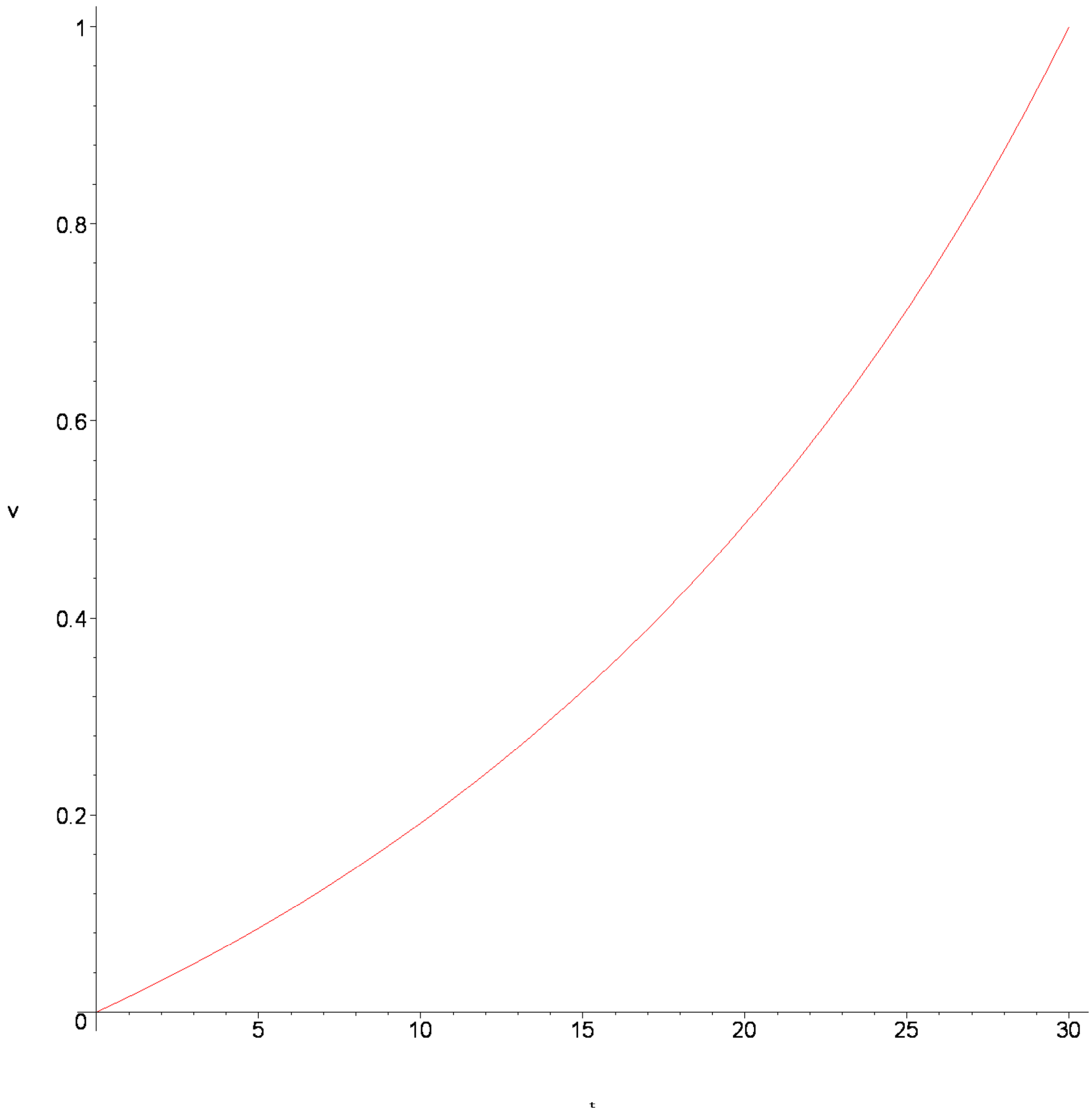
```
> dsol1(30);
```

$$[t = 30.,\ \mathrm{v}(t) = 1.]$$

```
> with(plots);
Warning, the name changecoords has been redefined
```

[*animate*, *animate3d*, *animatecurve*, *arrow*, *changecoords*, *complexplot*, *complexplot3d*, *conformal*, *conformal3d*, *contourplot*, *contourplot3d*, *coordplot*, *coordplot3d*, *cylinderplot*, *densityplot*, *display*, *display3d*, *fieldplot*, *fieldplot3d*, *gradplot*, *gradplot3d*, *graphplot3d*, *implicitplot*, *implicitplot3d*, *inequal*, *interactive*, *listcontplot*, *listcontplot3d*, *listdensityplot*, *listplot*, *listplot3d*, *loglogplot*, *logplot*, *matrixplot*, *odeplot*, *pareto*, *plotcompare*, *pointplot*, *pointplot3d*, *polarplot*, *polygonplot*, *polygonplot3d*, *polyhedra_supported*, *polyhedraplot*, *replot*, *rootlocus*, *semilogplot*, *setoptions*, *setoptions3d*, *spacecurve*, *sparsematrixplot*, *sphereplot*, *surfdata*, *textplot*, *textplot3d*, *tubeplot*]

```
> odeplot(dsol1);
```



Now for the expenses case. The following calculations yield the premium (explained in class)

```
> evalf( Int( exp(-0.045*t)*p(t), t=0..30 ));
```

15.85986176

```
> evalf(p(30)*exp(-0.045*30));
```

0.2190995663

```
> evalf(1-0.045*15.85986176);
```

$$0.2863062208$$

```
> evalf((0.004+1.002*.2863062208-0.0019*.2190
  995663)/15.85986176);
```

$$0.01831431751$$

```
> evalf((.1831431751e-1+0.0001)/0.99);
```

$$0.01860032072$$

Thiele's equation

```
> deq2 := diff(v(t),t) -
  (0.045+m(30+t))*v(t) - .1831431751e-1 +
  1.002*m(30+t)= 0;
```

$$deq2 := \left(\frac{d}{dt}\,\mathrm{v}(t)\right)$$
$$-\,(0.0455 + 0.00007585775\;10^{(1.140 + 0.038\,t)})\,\mathrm{v}(t)$$
$$-\,0.01781331751 + 0.00007600946550\;10^{(1.140 + 0.038\,t)} = 0$$

```
> tc2    := v(30) = 1.0001;
```

$$tc2 := \mathrm{v}(30) = 1.0001$$

```
> dsol2 := dsolve({deq2,tc2}, numeric,
  range=0..30);
```

$$dsol2 := \mathbf{proc}(x\_rkf45)\ \ldots\ \mathbf{end\ proc}$$

Note that the initial reserve must be -0.004

```
> dsol2(0);
```

$$[\,t = 0.,\ \mathrm{v}(t) = -0.00400005510669848574\,]$$

```
> dsol2(30);
```

$$[\,t = 30.,\ \mathrm{v}(t) = 1.00010000000000\,]$$

```
> dsol2(5);
>
```

$$[t = 5., v(t) = 0.0879686078256026184]$$

```
> dsol2(10);
```

$$[t = 10., v(t) = 0.200737660553129554]$$

```
> dsol2(15);
```

$$[t = 15., v(t) = 0.339186212109453654]$$

```
> dsol2(20);
```

$$[t = 20., v(t) = 0.510154601859010071]$$

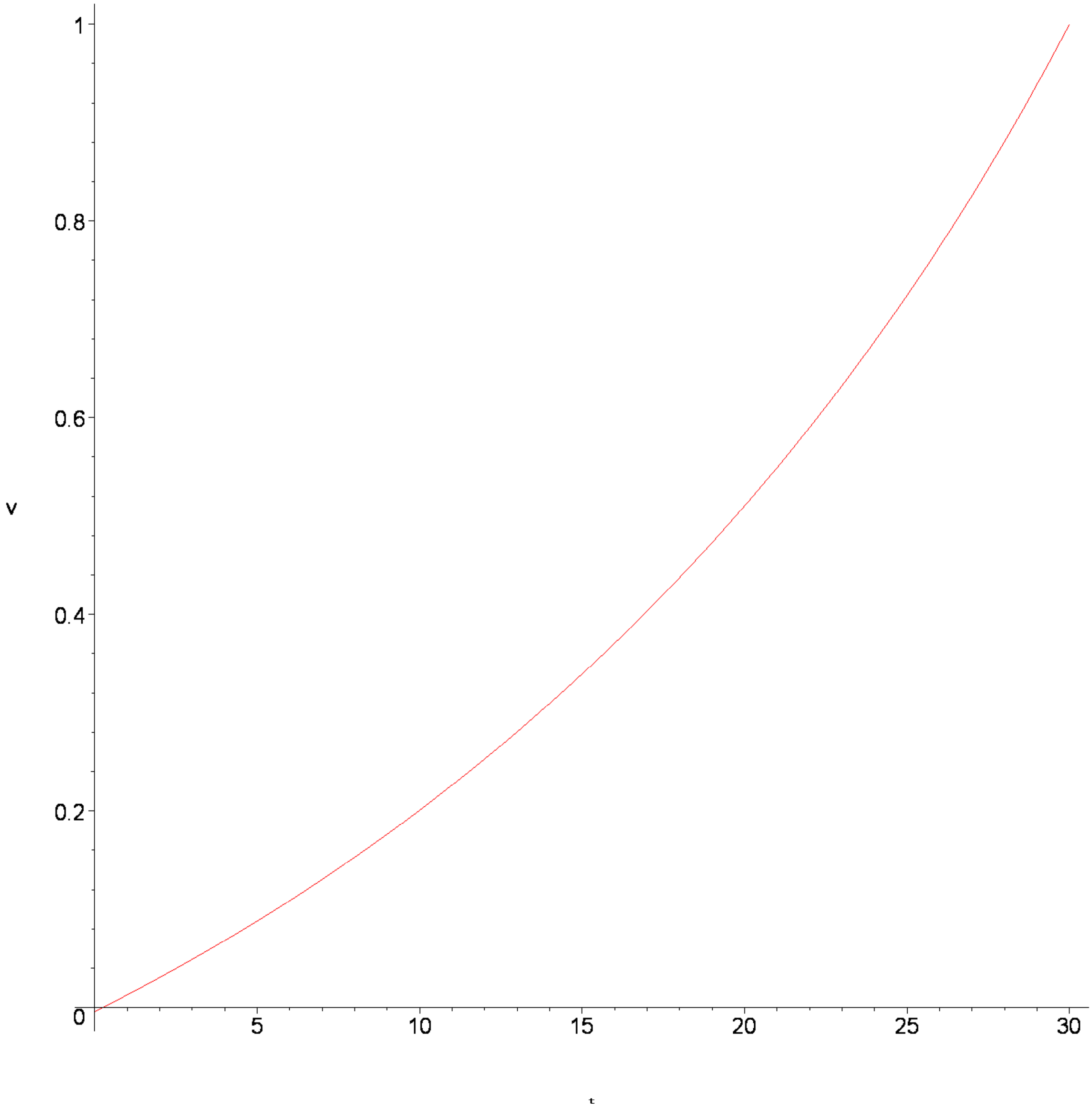
```
> dsol2(25);
```

$$[t = 25., v(t) = 0.724274783633621410]$$

```
> dsol2(30);
```

$$[t = 30., v(t) = 1.0001000000000]$$

```
> odeplot(dsol2);
```


1
0.8
0.6
0.4
0.2
0
v
5
10
15
20
25
30
t

>