```
> restart;
  with( plots ):
```

Maple Worksheet with Solution to Problem #8, Section 3.4, of Nagel and Saff

Prepared by Doug Meade
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We start with the differential equation and initial condition.

```
> ode := m*diff( v(t), t ) = m*g - k*v(t);
> ic := v(0)=0;
```

Here are the different sets of parameters for the different stages of the problem. First, for the free fall

```
> p1 := { m=100, g=981/100, k = 20 };
```

The resistance coefficient is larger when the parachute is opened.

```
> p2 := { m=100, g=981/100, k=100 };
```

The velocity is found as the solution to an IVP

```
> v1 := rhs( dsolve( { subs( p1, ode ), ic }, v(t) ) );
```

The position is found by integration (the constant C=-245 was determined by hand)

```
> x1 := int( v1, t )-245;
```

The velocity and position at t=30 minutes are needed as initial conditions for the second stage

```
> subs( t=30, [ v1, x1 ] );
> evalf( " );
> ic2 := v(30)=subs( t=30, v1 );
> ic2x := x(30) = subs( t=30, x1 );
```

After the parachute is open the velocity is given by

```
> v2 := rhs( dsolve( { subs( p2, ode ), ic2 }, v(t) ) );
```

and the position is given by

```
> x2 := rhs( dsolve( { diff( x(t), t ) = v2, ic2x }, x(t) ) );
> x2 := simplify( x2 );
```

Note that this is a little different than we have done before. The same expression can be obtained by integrating v2, then finding the value of the constant which makes value of the antiderivative agree with the position at the end of 30 seconds. The differential equation approach is simpler in that solving for the constant is automatic. (The next 3 lines show how I would find the position by integration.)

```
> #x2 := int( v2, t );
> #solve( subs( t=30, x2+C=x1 ) );
> #x2 := x2+";
```

Let’s look at the solutions

```
> Px1 := plot( x1, t=0..30 ):
  Pv1 := plot( v1, t=0..30 ):
> Px2 := plot( x2, t=30..100 ):
  Pv2 := plot( v2, t=30..100 ):
> display( {Pv1, Pv2 }, title=‘velocity‘ );
  display( { Px1, Px2 }, title=‘position‘ );
```

Note that both functions are continuous. The abrupt change in the velocity and displacement occur exactly when the parachute opens. Do you see how this makes sense?

And finally, to find the time of impact with the ground we need to find the time when x=3000. (Note that this time will be after 100 seconds; the plots show that the position after 100 seconds is nowhere close to 3000 m.)

```
> fsolve( x2=3000, t );
```

The entire jump took 206.7 seconds (3 minutes, 26.7 seconds).

The other part of this problem can be solved in EXACTLY the same manner. I think the only change that is needed is to convert every occurrence of t=30 with t=60.

END OF WORKSHEET