Maple Assignment Fall 1999 : Subway Schedule

This problem seeks to determine minimum time needed for a subway train to move between stations. The speed and distance parameters for the engineer to follow are determined by the Maple program. The train starts at station A, moves 1000 m to station B a distance of xb. The total time for the trip is to be minimized with the comfort and safety of the passengers as design constraints..   The train in each sequence starts from rest, accelerates at a constant rate, moves at this constant speed, then decelerates at a constant rate to a stop. Deceleration is 2 m/s^2. A design parameters are: the time interval for constant speed travel should be 80% of the total moving time, the starting acceleration should not exceed 4 m/s^2, and the maximum speed should not exceed 60 miles per hour (26.82 m/s). The unknowns are: a1, vmax1, x1, x2, t1, t2 for travel between the stations.   The intermediate distances are x1 and x2 , and the corresponding intermediate times are t1 and t2,.   The object is to make the total trip in a minimal time adjusting the the time parameter ttotal, which is to be a minimum. Thia is done by trial and error. Decrease the value from 100 seconds until a minimum is reached. Going below this minimum will result in answers that are not physical or violate the design parameters.

```
> ttotal:=64.6; a2:=-2.0;xb:=1000;t2:=t1+0.8*ttotal;
```

Next, we insert the kinematic equations for the trip from A to B:
```
> eq1:=a1*t1 -vmax1;
  eq2:= x1 -0.5*a1*t1^2;
  eq3:=vmax1*(t2-t1)-(x2-x1);
  eq4:=vmax1+a2*(ttotal-t2);
  eq5:=vmax1*(ttotal-t2)+0.5*a2*(ttotal-t2)^2-(xb-x2);
```

$$ttotal := 64.6$$
$$a2 := -2.0$$
$$xb := 1000$$
$$t2 := t1 + 51.68$$
$$eq1 := a1\, t1 - vmax1$$
$$eq2 := x1 - .5\, a1\, t1^2$$
$$eq3 := 51.68\, vmax1 - x2 + x1$$
$$eq4 := vmax1 - 25.840 + 2.0\, t1$$
$$eq5 := vmax1\,(12.92 - t1) - 1.00\,(12.92 - t1)^2 - 1000 + x2$$

We now sovle the above five equations for the unknowns by the following statement
```
> fsolve({eq1=0,eq2=0,eq3=0,eq4=0,eq5=0},{a1,vmax1,t1,x1,x2});
```
$$\{a1 = 3.981386223, t1 = 4.320068799, vmax1 = 17.19986240, x1 = 37.15229446,$$
$$x2 = 926.0411833\}$$

The problem is done, but we need to record the solution in the three regions of the motion by the following statements that use conditional statements:
```
> x:= proc(t) if t<=4.32 then 0.5*3.98*t^2 else if t>4.32 and t<56.0
  then 37.15+17.2*(t-4.32) else if t>=56.0 then 926.0+17.2
  *(t-56.0)+0.5*a2*(t-56.0)^2 fi fi fi end:
  v:= proc(t) if t<=4.32 then 3.98*t else if t>4.32 and t<56.0 then
  17.2 else if t>=56.0 then 17.2 -2*(t-56.0)fi fi fi end:
  a:=proc(t) if t<=4.32 then 3.98 else if t>4.32 and t<56.0 then 0.0
  else if t>=56.0 then -2 fi fi fi end:
```
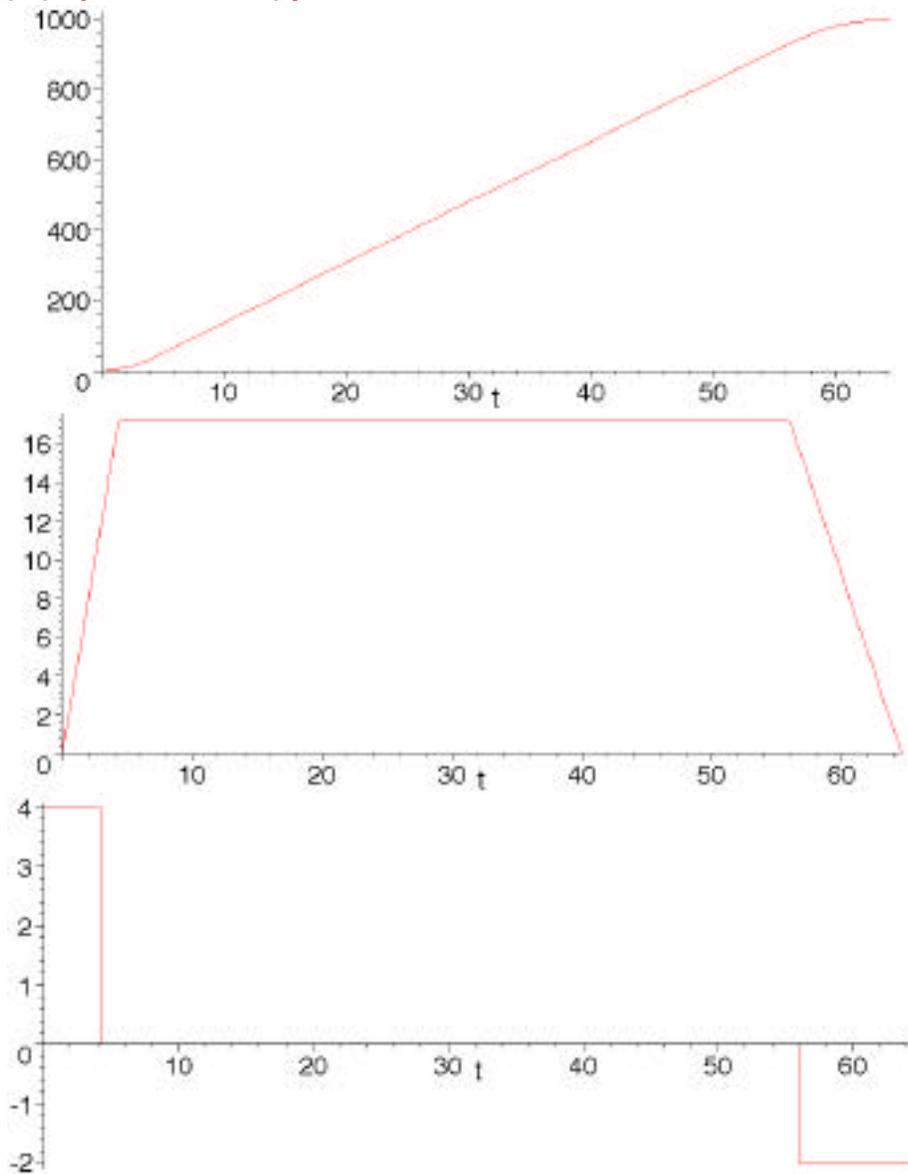
Now the plots:
```
>   plot('x(t)',t=0..64.6);
```
Now the plots:
```
>   plot('v(t)',t=0..64.6);
```
Now the plots:
```
>   plot('a(t)',t=0..64.6);
```