Prob. 4.16

Define angle, stress, strain, compliance as functions of time:

```
> Theta:=t -> gamma(t)*l/r;
```

$$\Theta := t \to \frac{\gamma(t)\, l}{r}$$

```
> sigma:=Gamma/(2*Pi*r^2*b);
```

$$\sigma := \frac{1}{2}\,\frac{\Gamma}{\pi\, r^2\, b}$$

```
> unprotect(gamma):gamma:=t -> J(t)*sigma;
```

$$\gamma := t \to J(t)\,\sigma$$

```
> J:=t -> (.75+.15*log10(t)+.018*(log10(t))^2)/1e9;
```

$$J := t \to .75\ 10^{-9} + .15\ 10^{-9}\ \log10(t) + .18\ 10^{-10}\ \log10(t)^2$$

Set values of numerical parameters:

```
> Digits:=4:l:=2;r:=.04/2;Gamma:=8;b:=.002;
```

(1) Compute angle after 20 hrs at 20C:

```
> 'Theta(deg)'=evalf((180/Pi)*Theta(20*3600));
```

$$\Theta(deg) = 17.36$$

(2) Compute effective time and angle for 60C:

```
> a_60:=.001;t_60:=20*3600/a_60;
> 'Theta(deg)'=evalf((180/Pi)*Theta(t_60));
```

$$\Theta(deg) = 27.72$$

(3) Compute effective time and twist for two-step temperature program:

```
> t_eff:=19.75*3600+(.25*3600)/a_60;
> 'Theta(deg)'=evalf((180/Pi)*Theta(t_eff));
```

$$\Theta(deg) = 20.91$$