Key: 9/4/20 Thompson

1-4 see the Hagen solutions manual

1. (10 pts) Problem 2.1.a – 2.1.j in Hagen.
2. (10 pts) Problem 2.11 in Hagen.
3. (10 pts) Problem 2.23 in Hagen.
4. (10 pts) Problem 2.35 in Hagen.

Problem 5 a

```
clear
u=symunit;
x=7925*u.ft*u.lbf;                    %part a
x=vpa(unitConvert(x,u.kJ))
```

x = 10.74485724052634817 kJ

```
x=650*u.J/u.s;                        %part b
x=vpa(unitConvert(x,u.Btu/u.min))
```

x =

$$36.964867692219370800498616734549\ \frac{\mathrm{Btu_{IT}}}{\mathrm{min}}$$

```
x=56*u.lbf/(u.in)^2;                  %part c
x=vpa(unitConvert(x,u.kPa))
```

x = 386.10640841742823485646971293943 kPa

```
x=25*(u.m)^3;                         %part d
x=vpa(unitConvert(x,u.gal))
```

x = 6604.30130895371038449749804022 91 gal

```
x=15956*u.ft;                         %part e
x=vpa(unitConvert(x,u.km))
```

x = 4.8633888 km

```
x=250*u.W;                           %part f
x=vpa(unitConvert(x,u.Btu/u.h))
```

x =

$$853.03540828198548001150654002805\ \frac{\mathrm{Btu_{IT}}}{\mathrm{h}}$$

```
x=176*u.slug/u.min;                    %part g
x=vpa(unitConvert(x,u.kg/u.s))
```

x =

$42.808781949138670166229221347332 \ \frac{kg}{s}$

```
x=47*u.Celsius                          %part h
```

x = 47 °C

```
x=vpa(unitConvert(x,u.Rankine,'Temperature','absolute'))  %Important - the default on t
```

x = 576.27 °R

```
x=1500*u.Fahrenheit          %part j dang, it's hard to spell Fahrenheit!
```

x = 1500 °F

```
x=vpa(unitConvert(x,u.Celsius,'Temperature','absolute'))
```

x = 815.555555555555555555555555556 °C

```

```

6. (20 pts) Eurostar is a high speed rail service that connects London to Paris. The dis
from London to the English Channel Tunnel is 108.0 km. The English Channel Tu
50.5 km long. The distance from the English Channel Tunnel to Paris is 316.0 km.
travels at a maximum speed of 300 km/hr except within the English Channel Tunn
a reduced speed of 160 km/hr is required for safety reasons.
   a. How long does the journey from London to Paris take? Give you answer in mi
   b. If the resistance between the train and the track at maximum speed is 120 kN
      resistance adds an additional 20.5 kN (Note: Power = force × velocity), what i
      power in horsepower required to power the engine?
   c. In Japan, the modification of the nose of their high speed train by mimicking t
      of the kingfisher's beak reduced air resistance by 30%. What would be the per
      reduction in horsepower required to power the Eurostar's engine?

Solution:

The general equation needed is that the distance traveled is given by $d = v_{avg}T$ where v_{avg} is the average velocity and $T$is the travel time. Rearranging, we compute the travel time for each leg of the trip using $T = \frac{v_{avg}}{d}$ and then sum them to find the total trip time.

```
clear
```

```
u=symunit;

dLT=108*u.km; %Distance from London to Tunnel
dT=50.5*u.km; %Length of tunnel
dPT=316*u.km; %Distance from Paris to Tunnel
v0=300*u.km/u.h;
v_tunnel=160*u.km/u.hr;

ttLT=dLT/v0;    %travel time; Governing equation d=v*t: Assuming average velocity
ttT=dT/v_tunnel;
ttPT=dPT/v0;
tt=ttLT+ttT+ttPT; %sum the three legs of travel
tt=vpa(unitConvert(tt,u.min))  %google reports estimated time of 2.5 hours - there are
```

tt = 103.7375 min

```
tt=vpa(unitConvert(tt,u.h))
```

tt = 1.728958333333333333333333333333333 h

```
Ft=120*u.kN+20.5*u.kN ;  %total resistant force:

P=Ft*v0;   %Avg power at high speed
P=vpa(unitConvert(P,u.hp))
```

P = 15918.903102599879800629556743737 HP_{DIN}

```
Ft=120*u.kN+20.5*0.7*u.kN;   %30% reduction in air resistance
PJ=Ft*v0;
PJ=vpa(unitConvert(PJ,u.hp))
```

PJ = 15222.097023731628834267480060648 HP_{DIN}

7. (20 pts) In August 2017, Hurricane Harvey dumpe
western half of the United States sees all year [1].
Harvey over Texas, Louisiana, Tennessee, and Ke
[2]. One trillion is 1×10^{12}.

a. If this volume of water were collected into a cube, how long would each cube be in km? Show your work.
b. If that volume of water covered the state of Kansas (52.657 million acres), would the water be, in ft?

Governing equation: for a cube $V = x^3$ for a cube. And $V = A \cdot d$ for the "depth" question.

```
clear;
u=symunit;
sym x;
V=33e12*u.gal;
x=V^(1/3);
x=vpa(unitConvert(x,u.km));
x=simplify(x)
```

x = 4.998914282553923118021045728665 8 km

```
x=vpa(unitConvert(x,u.mi))
```

x = 3.106181327642768182576904458379 2 mi

```
A=52.657e6*u.acre;
d=V/A;            %d = depth of water in Kansas
d=vpa(unitConvert(d,u.ft))
```

d = 1.923260879809866649223239989899 7 ft

```
A=669*(u.mi)^2;    % Out of curiosity...This is the size of the Houston area. If all the
d=V/A;
d=vpa(unitConvert(d,u.ft))
```

d = 236.531082184576205502961855727 18 ft