FYS-MEK 1110 - Oblig 1

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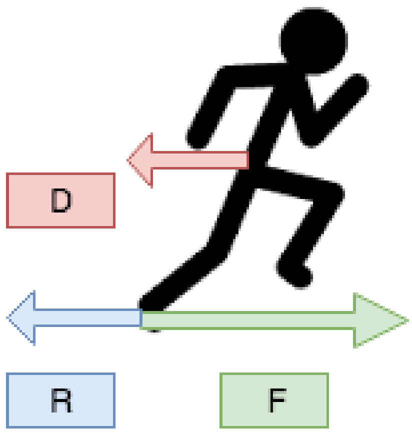
a)



Figur 1: Free Body Diagram of a person running.(Drawn with draw.io)

b)

Since acceleration is the double derivative og position, I can use Newtons second law to find an ecpression for acceleration, and then integrate it twice.

$$F = ma$$
$$a = \frac{F}{m}$$
$$a = \frac{400N}{80kg} = 5m/s^2$$

$$a(t) = v'(t)$$

$$v(t) = \int a(t)dt$$

$$v(t) = \int 5dt$$

$$v(t) = 5t$$

$$x(t) = \int v(t)dt$$

$$x(t) = \int 5tdt$$

$$x(t) = 2.5t^2$$

c)

To find the time after 100 meters I just need to flip around my function for position and input 100 meters.

$$x(t) = 2.5t^2$$

$$t^2 = \frac{x(t)}{2.5}$$

$$t = \sqrt{\frac{x(t)}{2.5}}$$

$$t = \sqrt{\frac{100}{2.5}}$$

$$t = 6.32s$$

d)

Expression for D and value of F given in the task:

$$D = (1/2)pCdA(v - w)^2$$

$$F = 400N$$

Now I find the sum of horzontal forces by subracting D from F, and using Newtons second law(F=ma) I can find an expression for a

$$\sum F_x = F - D$$

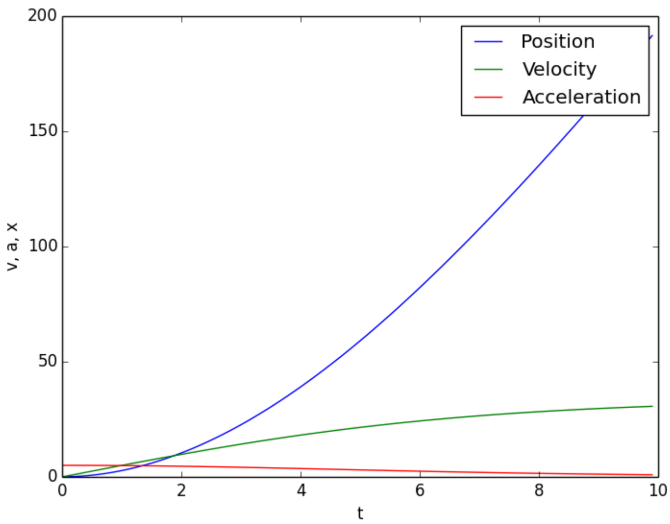
$$= 400N - 0.5 * 1.293kg/m^3 * 1.2 * 0.45m^2v^2 = m * a$$

$$a(t) = \frac{400N - 0.5 * 1.293kg/m^3 * 1.2 * 0.45m^2v^2}{80kg}$$

$$a(t) = \left(\frac{-0.6 * 1.293 * 0.45}{80} v(t)^2 + 5 \right) m/s^2$$

(I put 0 in for w in the air resistance formula since nothing else was specified)

e)



Figur 2: Graph plotting position, velocity and acceleration.

```python
import numpy as np
import matplotlib.pylab as plt

winTime = 0
n = 100
dt = 10.0 / n

t = np.zeros(n)
x = np.zeros(n)
v = np.zeros(n)
a = np.zeros(n)

t[0] = 0
x[0] = 0
v[0] = 0
a[0] = 5

for i in range(n-1):
    a[i+1] = (-0.6*1.293*0.45)/80 * v[i]**2 + 5
    v[i+1] = v[i] + dt*a[i]
    x[i+1] = x[i] + dt*v[i+1]
    t[i+1] = t[i] + dt

    if x[i+1] >= 100 and winTime == 0:
        winTime = t[i+1]
        print "Run finished in %f seconds" %(winTime)

plt.plot(t, x, t, v, t, a)
plt.legend(["Position", "Velocity", "Acceleration"])
plt.xlabel("t")
plt.ylabel("v, a, x")
plt.savefig("taskE.png")
```

f)

(See figure in task E) I added an if-statement to the for-loop that checks if x ¿= 100, and print the time when it is. It returns 6.8 seconds.

g)

With the model given in this task terminal velocity is reached when the drag-force is equal to the driving force:

$$F = D$$

$$F = 1/2pCdAv_T^2$$

$$2F = pCdAv_T^2$$

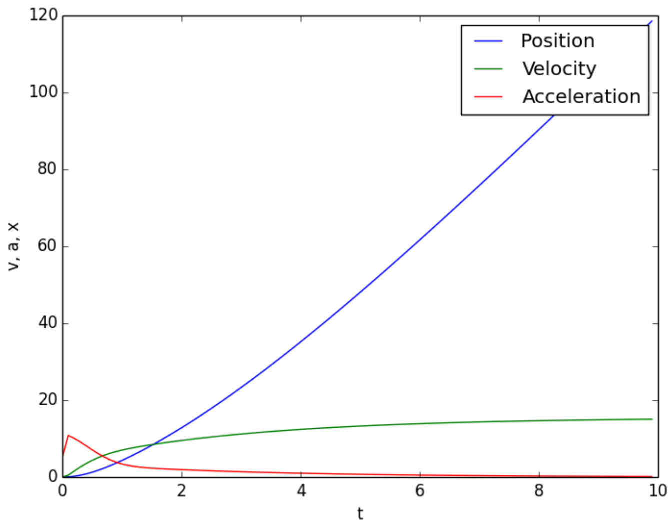
$$\frac{2F}{pCdA} = v_T^2$$

$$v_T = \sqrt{\frac{2F}{pCdA}}$$

And this is what we were supposed to show.

h)

i)



Figur 3: Graph plotting position, velocity and acceleration with a more realistic model.

```
import matplotlib.pylab as plt
import numpy as np

winTime = 0
n = 100
dt = 10.0 / n

t = np.zeros(n)
x = np.zeros(n)
v = np.zeros(n)
a = np.zeros(n)

t[0] = 0
x[0] = 0
v[0] = 0
a[0] = 5

for i in range(n-1):
    t[i+1] = t[i] + dt

    v[i+1] = v[i] + dt*a[i]

    a[i+1] = (400+488*np.exp(-(t[i+1]/0.67)**2)-25.8*v[i+1]-0.5*0.45*(1-0.25*np.exp(-(t[i+1]/0.67)**2)*1.293*1.2*v[i+1]**2))/80

    x[i+1] = x[i] + dt*v[i+1]

    if x[i+1] >= 100 and winTime == 0:
        winTime = t[i+1]
        print "Run finished in %f seconds" %(winTime)

plt.plot(t, x, t, v, t, a)
plt.legend(["Position", "Velocity", "Acceleration"])
plt.xlabel("t")
plt.ylabel("v, a, x")
plt.savefig("taskI.png")
```

j)

After the changes he runs 100m in 8.7 seconds.

k)

The air resistance has a much less significant effect on the total force. It makes sense that a runners own physical limitations stop him before air resistance does.

l)

The resulting time of the 100m run will remain approximately the same even with wind speeds of 1m/s or -1m/s. This correlates with the results of task K which said the air drag force is insignificant.