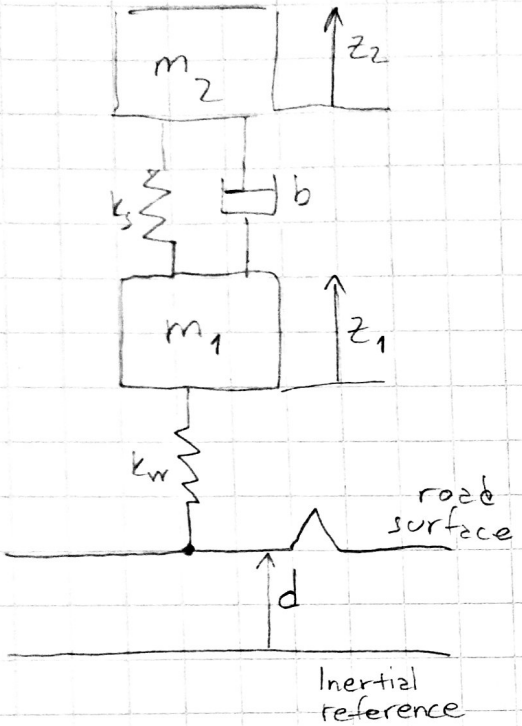
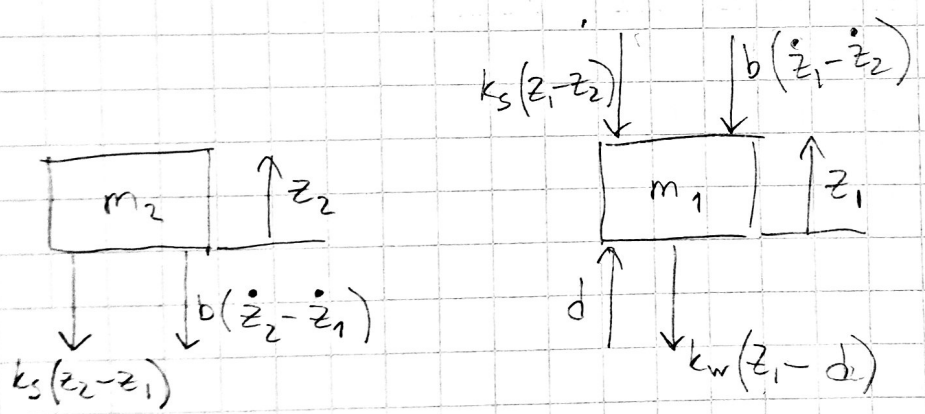
Assignment 2

①



- Damping b and stiffness k forces are against the displacement z
- Bump in road surface works as an input



a/

Output: z_1 , z_2

Input: d

Constant: m_1 , m_2 , k_s , k_w , b

Internal time varying variables:

b/

$$ma = \sum F$$

$$m_2 \ddot{z}_2 = -k_s(z_2 - z_1) - b(\dot{z}_2 - \dot{z}_1)$$

$$m_1 \ddot{z}_1 = -k_w(z_1 - d) - k_s(z_1 - z_2) - b(\dot{z}_1 - \dot{z}_2)$$

$$x_1 = z_1$$
$$x_2 = z_2$$
$$x_3 = \dot{z}_1$$
$$x_4 = \dot{z}_2$$

$$\dot{x}_1 = \dot{z}_1 = x_3$$

$$\dot{x}_2 = \dot{z}_2 = x_4$$

$$\dot{x}_3 = \ddot{z}_1 = \frac{-k_w(x_1 - d) - k_s(x_1 - x_2) - b(x_3 - x_4)}{m_1}$$

$$\dot{x}_4 = \ddot{z}_2 = \frac{-k_s(x_2 - x_1) - b(x_4 - x_3)}{m_2}$$

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \end{pmatrix} = \begin{pmatrix} x_3 \\ x_4 \\ \left(-k_w(x_1 - d) - k_s(x_1 - x_2) - b(x_3 - x_4)\right)/m_1 \\ \left(-k_s(x_2 - x_1) - b(x_4 - x_3)\right)/m_2 \end{pmatrix}$$

c/

Matlab files SuspenseSystemODE.m & rhs.m

Plot 1 at the end of the document

d/

Files SuspenseSystem.mdl & constants 1m.

Plot 2 at the end of the document

c = kohte θ => rad

$\alpha_4 = 51,36$
$\alpha_3 = 30,26$

(2.)

throttle input u input
vehicle speed v output

Model:

$$m\frac{dv}{dt} = \alpha_n u T(\alpha_n v) - mg C_r sgn(v) - \frac{1}{2}\rho C_d A v^2 - mg\sin\theta$$

torque:

$$T(\omega) = T_m\left(1 - \beta\left(\frac{\omega}{\omega_m} - 1\right)^2\right)$$

$\alpha_3 = 16$
$m = 800\ kg$
$u = 0,7$
$g = 9,8\ m/s^2$
$T_m = 190\ Nm$
$\omega_m = 420\ rad/s$
$\beta = 0,4$
$C_r = 0,01$
$C_d = 0,32$
$A = 2,4\ m^2$
$\rho = 1,3\ kg/m^3$
$\theta = 0$

$$\Rightarrow \frac{dv}{dt} = \left(\alpha_n u T\left(1 - \beta\left(\frac{\alpha_n v}{\omega_m} - 1\right)^2\right) - mg C_r sgn(v) - \frac{1}{2}\rho C_d A v^2 - mg\sin\theta\right)/m$$

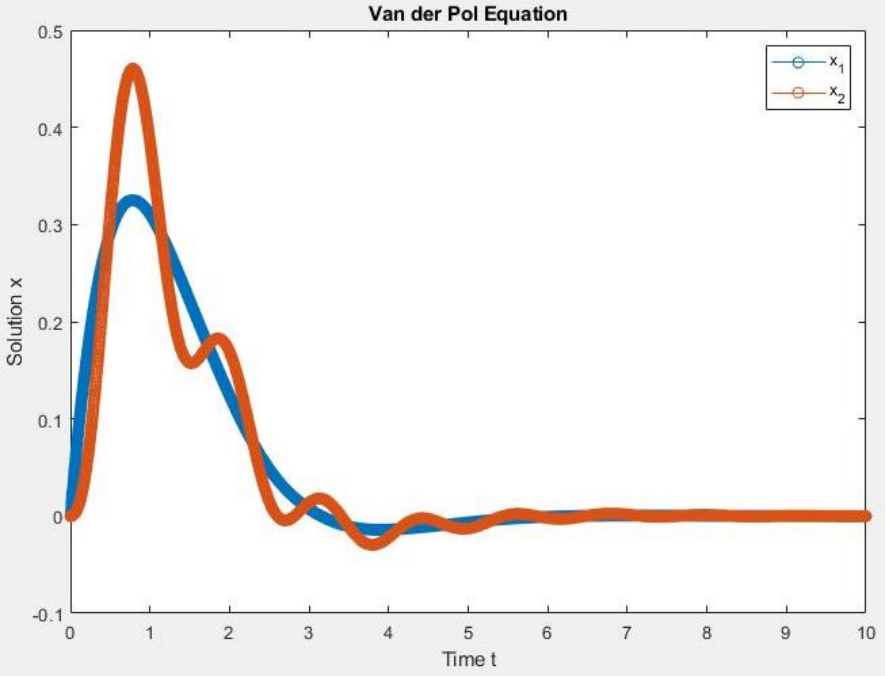
b/
answer: 50,95 m/s

Plot 3 at the end of document

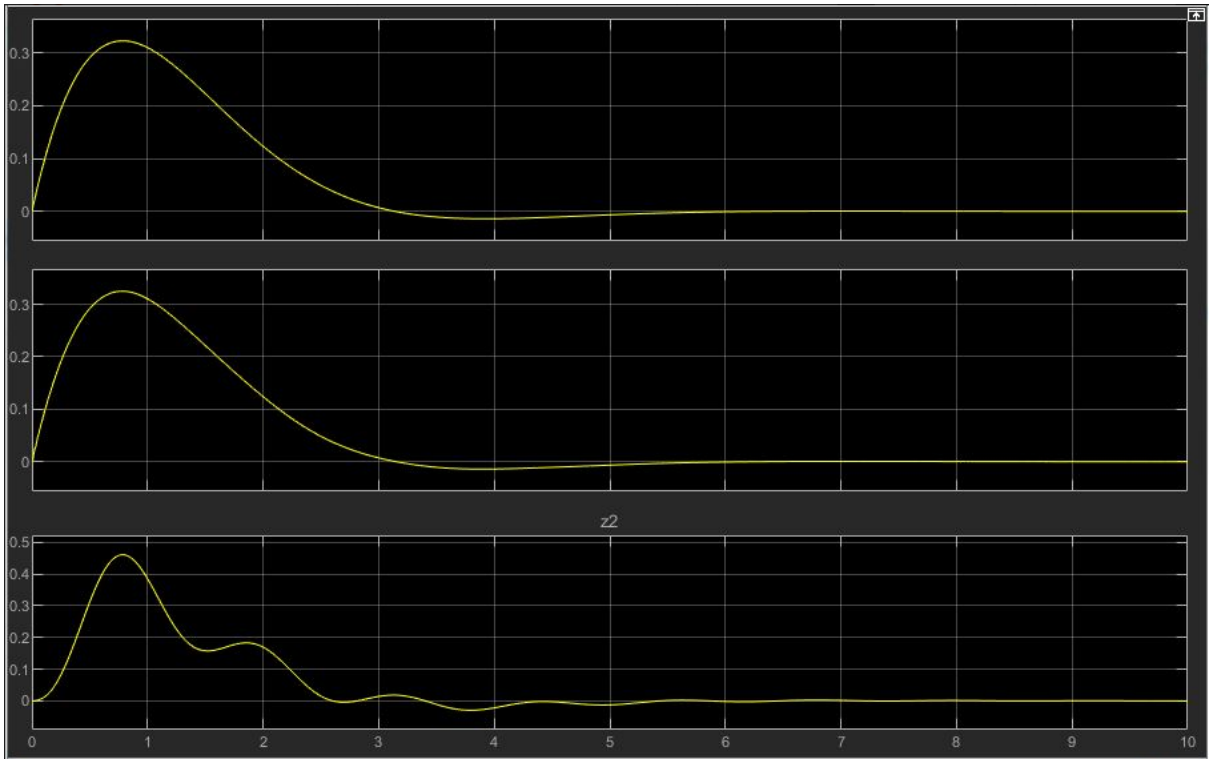
c/

changing to gear 4 ($a_4 = 12$) and increasing the throttle $v = 0{,}9853$ we get the same $v = 50{,}95$ as on the flat surface

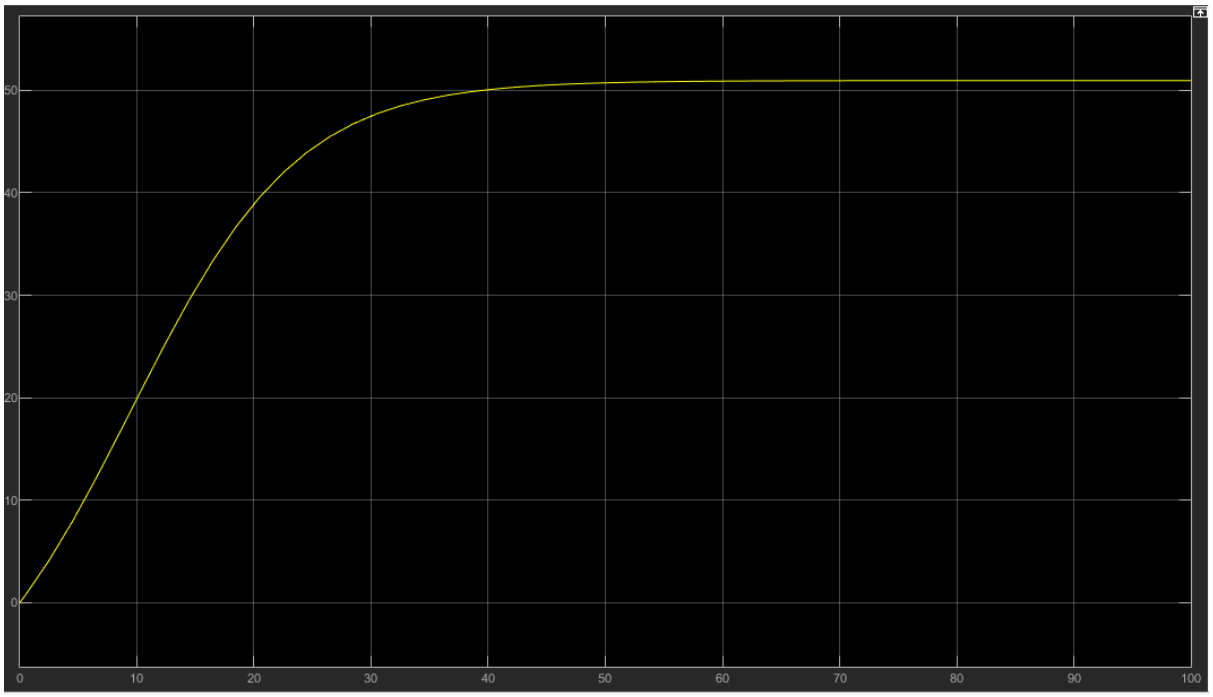
plot 4 at the end of the document



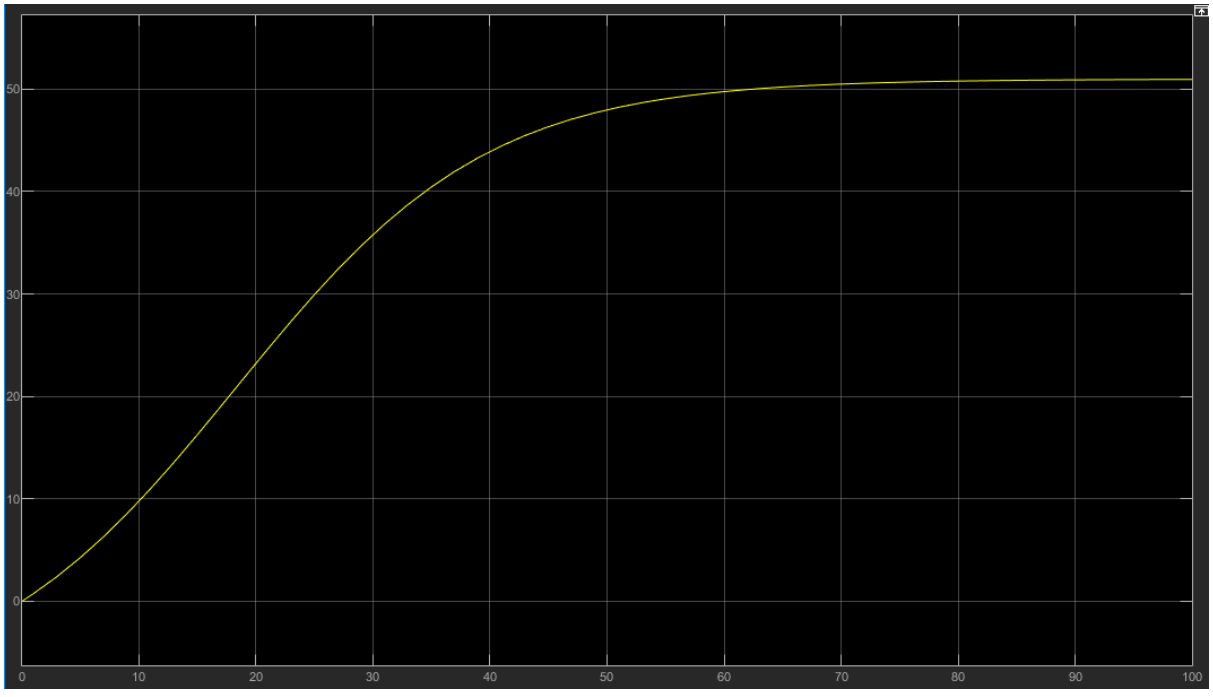
Plot 1. Problem 1



Plot 2. Problem 1



Plot 3. Problem 2



Plot 4. Problem 2 with a4 = 12 and u = 0.9853