



دفتري فيرست : تحكم آلي Automation

حلا

للطالبة

اللجنة الأكاديمية لقسم الهندسة الصناعية

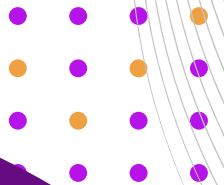
2025



Turbo IEG.Com



Turbo Team Youtube



Systems

mechanical

Electrical

Translational motion

Rotational motion

kcl kl

$$\sum F = ma$$

$$\sum T = J\ddot{\theta}$$

F: Force

T: Torque

M: mass

J: inertia

A: acceleration

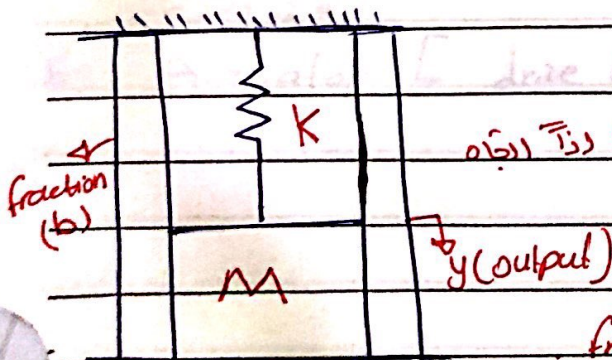
$\ddot{\theta}$: angular acceleration

أو ممكن يطلب السؤال عنك على حسب القوانين

- 1- Derive the equation of motion of system.
- 2- Derive the mathematical or governing equation system.

example:

① الحل / بأي أول أسس بعد نضع المعاد والقانون بالمثل انه القوة
Translation ذلك حاسم قانونها.



② عندي قوة للاسفل والفتوح مربوط بـ spring ذلك اتجاه
القوة الزنبرك دائماً عكس اتجاه القوة

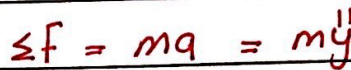
③ المرنك ملوث بلول اننا في امكان نضع اسهل fraction

F (input)

$$F_{\text{spring}} = Kx$$

$$F = by$$

Handelskredit =

$$\frac{V}{R} = \frac{T}{R}$$
~~10.6.2 $\frac{1}{2} = \frac{1}{2} \cdot \text{relativ}$~~ ~~$\psi = \frac{1}{2} \ln \frac{1+\eta}{1-\eta}$~~ 

* Mg^{2+} is 10% lower than Ca^{2+}

$$VI + 9I = 73$$

~~$$12 + 12 \times 2 \times \frac{1}{2} + \frac{1}{8} =$$~~

$$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$$

1.0

14-21-2014

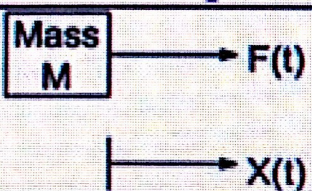
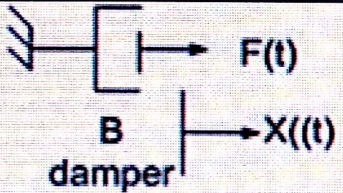
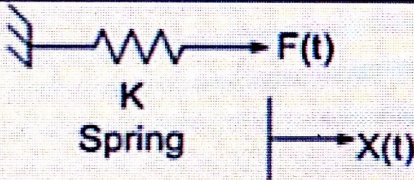
11/27/2014

11-2-1968

~~5/17/04 1.4 RV = 1.2~~
$$1 + \frac{1}{2} + 9\pi =$$

enters:

$$V_R = IR$$
$$L_{\text{eff}} = L \left(1 - \frac{1}{n} \right)$$
$$V_c = \frac{1}{C} \int I_c dt$$

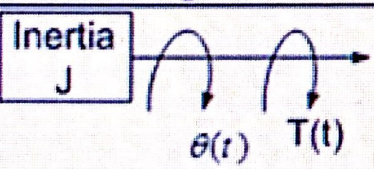
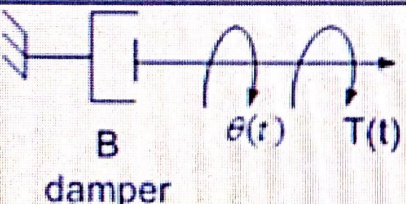
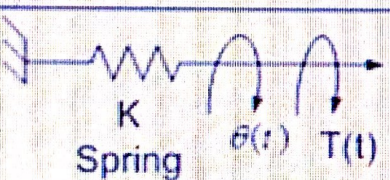
Component s	Time relation
	$F(t) = m \frac{d^2 x(t)}{dt^2}$
	$F(t) = B \frac{dx(t)}{dt}$
	$F(t) = kx(t)$

→ $\Sigma F = ma = m\ddot{x}$

→ $F = b\dot{x}$

→ $F = kx$

Mechanical Components: Rotational motion

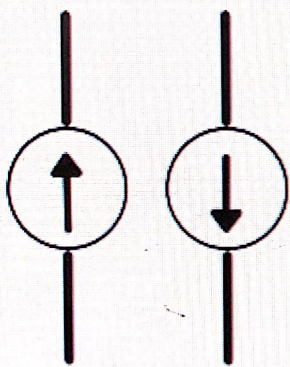
Components	Time relation
	$T(t) = J \frac{d^2 \theta(t)}{dt^2}$
	$T(t) = B \frac{d \theta(t)}{dt}$
	$T(t) = K \theta(t)$

→ $T = J\ddot{\theta}$

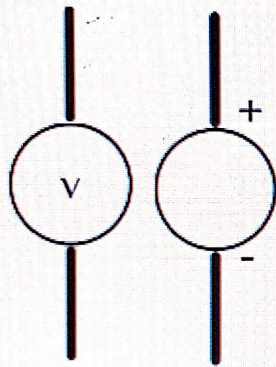
→ $T = b\dot{\theta}$

→ $T = k\theta$

رموز مكونات الدارة :



source
مصدر للتيار
والسهم يعبر عن
اتجاه التيار



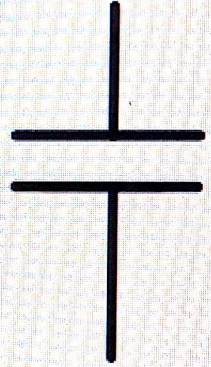
source
مصدر الجهد



Resistor
مقاومة $v=RI$

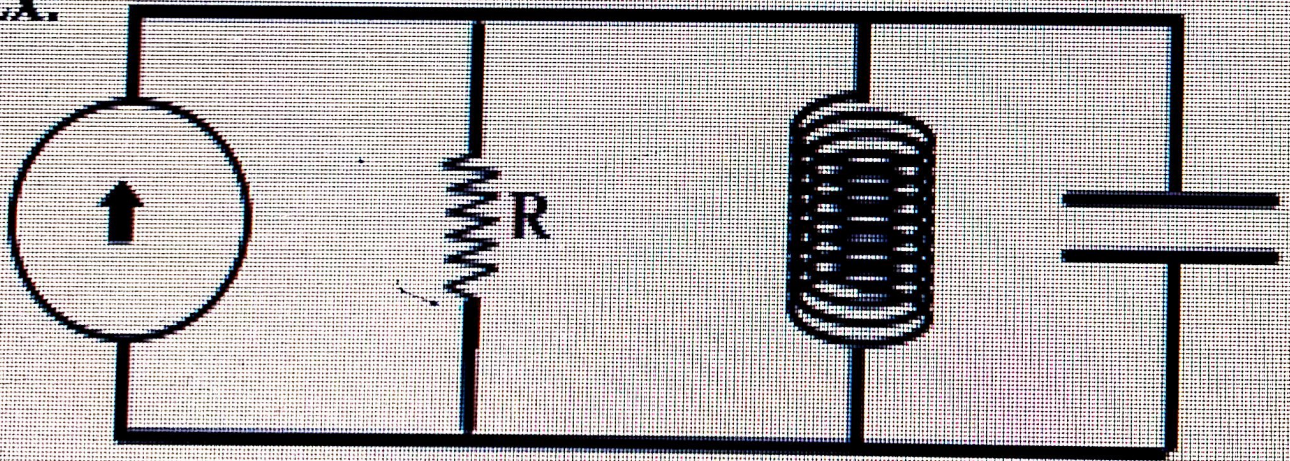


Inductor
محث $v=LI$



Capacitor
مواسع $I=CV'$

■ Ex:



► Subject :

- electrical element:

- resistor $I = \frac{V}{R}$

- Inductor $I_L = \frac{1}{L} \int v dt$

- capacitor $I_C = C \dot{V}$

Solution :

1- الدارة متسلسلة في التوازي

التيار المتساوي والباريتونج $P_m = P_m = 72$

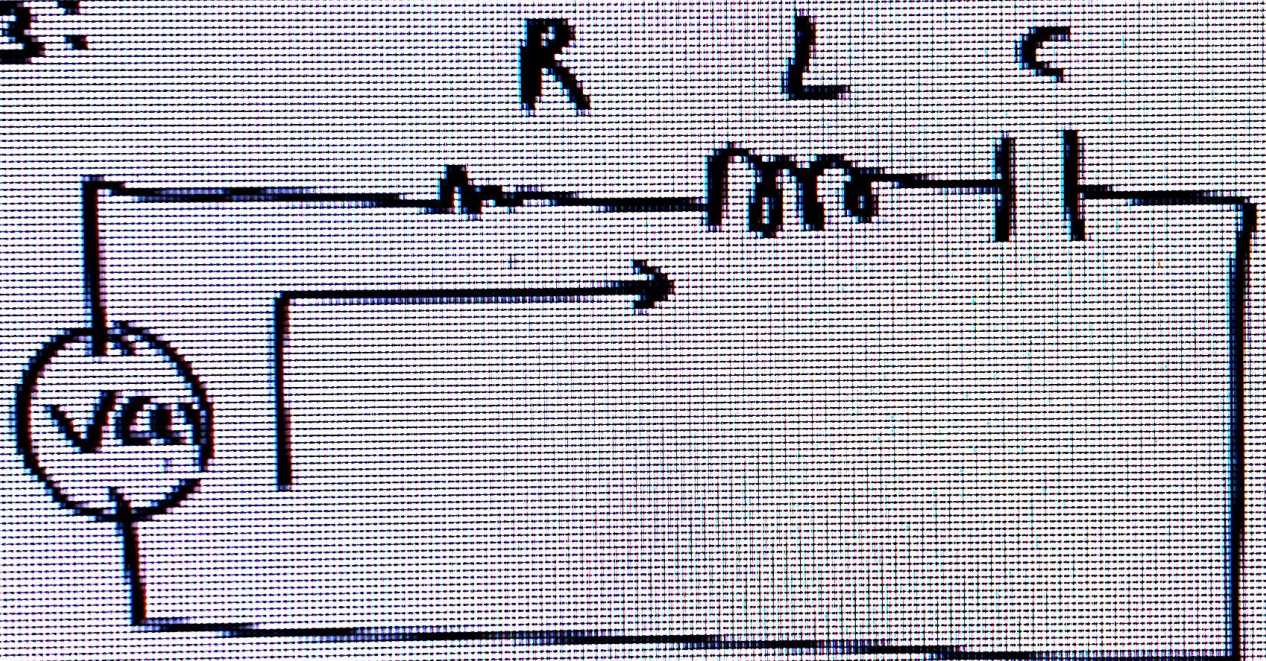
* لا يكون التيار Input والخرج output $P_m = P_m = 72$

$$\sum I = I_R + I_L + I_C = 0 \quad (4.57)$$

$$= \frac{V}{R} + \frac{1}{L} \int v dt + C \dot{V}$$

$$= \frac{\dot{V}}{R} + \frac{V(1)}{L} + C \ddot{V} + j\omega L + j\omega C = 0 \quad (4.58)$$

EX 3:



Solution:

التي تم شحها على التوالي
التيار شبه والحد يتوزع.

التيار input output

$$\Sigma V = V_R + V_L + V_T$$

$$= IR + L \dot{I} + \frac{1}{C} \int i dt$$

$$= I'R + L \dot{I}' + \frac{1}{C} \int i' dt$$

بذلك يتحقق شرط
الحفاظ على الطاقة

التيار input output يتوزع على التوالي

$$I' = I$$

$$I' = I$$

x

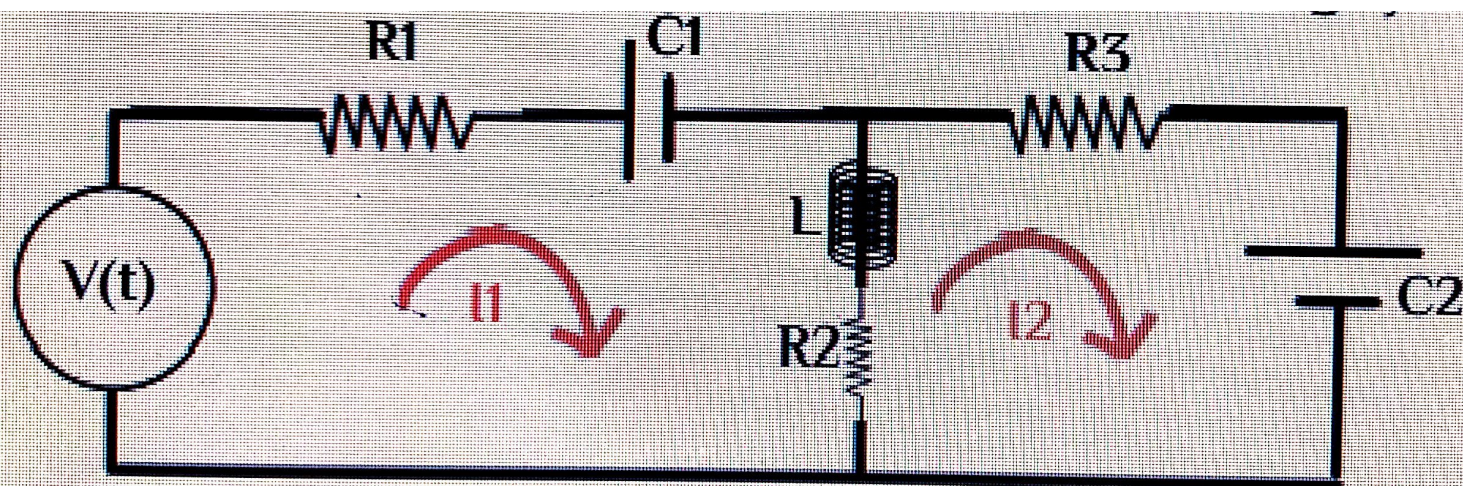
$$m \ddot{x} + kx + b\dot{x}$$

$$v = \dot{x}$$

$$m \dot{v} + ksv + bv$$

$$a = \ddot{x}$$

$$m a + kss a + bsa,$$

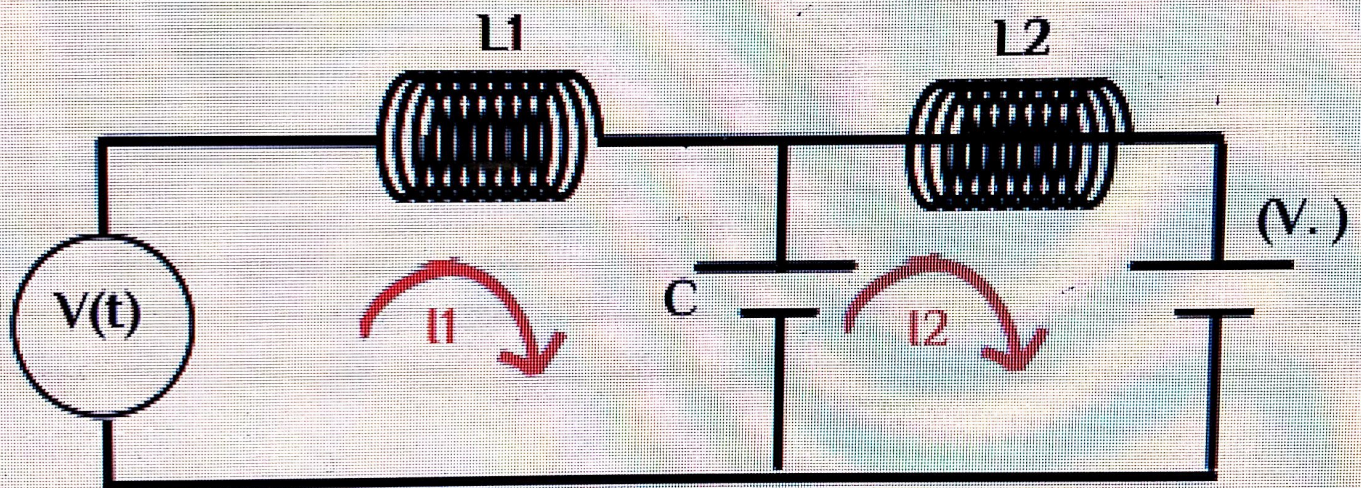


* write the differential equation of following system.

I have two loop then I have two solution:

Loop₁: $v(t) = v_{R1} + v_{C1} + v_{L1} + v_{R2}$
 $= iR_1 + \frac{1}{C_1} \int i(t) dt + L(i_1 - i_2)' + R_2(i_1 - i_2)$
 $\dot{v} = \dot{i}R_1 + \frac{i(t)}{C_1} + L(i_1 - i_2)'' + R_2(i_1 - i_2)'$

Loop₂: $v(t) = v_{R3} + v_{C2} + v_{R2} + v_{L2}$
 $= iR_3 + \frac{1}{C_2} \int i(t) dt + R_2(i_2 - i_1) + L(i_2 - i_1)'$
 $= \dot{i}R_3 + \frac{i(t)}{C_2} + R_2(i_2 - i_1) + L(i_2 - i_1)''$



Write the differential equation of the following system if the output is $i(t)$.

Loop 1:

$$V(t) = V_{L1} + V_C$$

$$= L \dot{i}_1 + \frac{1}{C} \int (i_1 - i_2) dt$$

$$= L \dot{i}_1 + \frac{(i_1 - i_2)}{C}$$

Loop 2:

$$V_{L2} + V_C = 0$$

$$L_2 \dot{i}_2 + \frac{1}{C} \int i_2 dt + \frac{1}{C} \int (i_2 - i_1) dt$$

$$L_2 \ddot{i}_2 + \frac{i_2(t)}{C} + \frac{(i_2 - i_1)}{C}$$

Loop 1 = Loop 2

$$= L_2 \ddot{i}_2 + \frac{i_2(t)}{C} + L \dot{i}_1$$

M1



K1

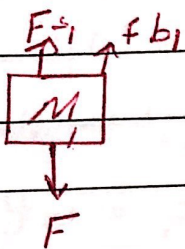
M2



K2

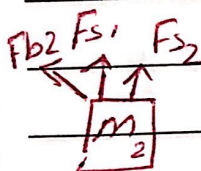
► Subject :

- Write the differential equation of following system.



$$\sum F = ma = m\ddot{y}$$

$$m\ddot{y} + k_1 (y_1 - y_2) + b_1 (y_1' - y_2') = 0$$



$$\sum F = ma = m\ddot{y}$$

$$m\ddot{y} + k_2 (y_2 - y_3) + b_2 (y_2' - y_3') + k_1 (y_2 - y_1) = 0$$

	$f(t)$	$\mathcal{L}(f)$		$f(t)$	$\mathcal{L}(f)$
1	Unit-impulse $\delta(t)$	$\begin{matrix} \longrightarrow 1 \\ \longleftarrow \end{matrix}$	7	$\cos \omega t$	$\begin{matrix} \longrightarrow \frac{s}{s^2 + \omega^2} \\ \longleftarrow \end{matrix}$
2	Unit-step 1	$\begin{matrix} \longrightarrow 1/s \\ \longleftarrow \end{matrix}$	8	$\sin \omega t$	$\begin{matrix} \longrightarrow \frac{\omega}{s^2 + \omega^2} \\ \longleftarrow \end{matrix}$
3	Unit-ramp t	$\begin{matrix} \longrightarrow 1/s^2 \\ \longleftarrow \end{matrix}$	9	$\cosh at$	$\begin{matrix} \longrightarrow \frac{s}{s^2 - a^2} \\ \longleftarrow \end{matrix}$
4	t^2	$\begin{matrix} \longrightarrow 2!/s^3 \\ \longleftarrow \end{matrix}$	10	$t e^{at}$	$\begin{matrix} \longrightarrow \frac{1}{(s - a)^2} \\ \longleftarrow \end{matrix}$
5	t^n (n is +ve integer)	$\begin{matrix} \longrightarrow \frac{n!}{s^{n+1}} \\ \longleftarrow \end{matrix}$	11	$e^{at} \cos \omega t$	$\begin{matrix} \longrightarrow \frac{s - a}{(s - a)^2 + \omega^2} \\ \longleftarrow \end{matrix}$
6	e^{at}	$\begin{matrix} \longrightarrow \frac{1}{s - a} \\ \longleftarrow \end{matrix}$	12	$e^{at} \sin \omega t$	$\begin{matrix} \longrightarrow \frac{\omega}{(s - a)^2 + \omega^2} \\ \longleftarrow \end{matrix}$

- 1st order Laplace : $L\left[\frac{df(t)}{dt}\right] = sF(s) - f(0) \Rightarrow L\left[\frac{df(t)}{dt}\right] = sF(s)$

- 2nd order Laplace : $L\left[\frac{df(t)^2}{dt^2}\right] = s^2F(s) - sf(0) - f'(0) \Rightarrow L\left[\frac{df(t)^2}{dt^2}\right] = s^2F(s)$

- 3rd order Laplace : $L\left[\frac{df(t)^3}{dt^3}\right] = s^3F(s) - s^2f(0) - sf'(0) - f''(0) \Rightarrow L\left[\frac{df(t)^3}{dt^3}\right] = s^3F(s)$

Find $x(t)$ At initial condition, let $\frac{k}{m} = 2$, $\frac{b}{m} = 3$, $f(t) = 1$

$$F = m\ddot{y} + b\dot{y} + ky$$

1] solution:

$$F(t) = m\ddot{y} + ky + b\dot{y} / m$$

$$\frac{F(t)}{m} = \frac{m\ddot{y}}{m} + \frac{ky}{m} + \frac{b\dot{y}}{m}$$

$$1 = \ddot{y}(t) + 2\dot{y}(t) + 3y(t)$$

$$2A = 1 \rightarrow A = \frac{1}{2}$$

$$-1(C)(1) = 1 \rightarrow C = -1$$

$$B(-2)(-1) = 1 \rightarrow B = \frac{1}{2}$$

من أجل إيجاد A, B, C

A, B, C

2] نأخذ Laplace الطرفين

$$\int_{-\infty}^{\infty} \frac{1}{s} = \int_{-\infty}^{\infty} \ddot{y}(t) + \int_{-\infty}^{\infty} 2\dot{y}(t) + \int_{-\infty}^{\infty} 3y(t)$$

$$\frac{1}{s} = s^2 y(s) + 2s y(s) + 3s y(s)$$

من أجل إيجاد A, B, C

A, B, C

3] نأخذ Laplace الطرفين

$$y(s) (s^2 + 2s + 3s) = \frac{1}{s}$$

$$y(s) = \frac{1}{s(s^2 + 3s + 2)}$$

$$\int \frac{1}{s(s^2 + 3s + 2)} = \int \frac{\frac{1}{2}}{s} + \int \frac{\frac{1}{2}}{s+2} + \int \frac{-1}{s+1}$$

$$y(t) = \frac{1}{2} + \frac{1}{2} e^{-2t} - e^{-t}$$

4] نأخذ Laplace الطرفين

Subject :

$$y(s) = \frac{2}{(s+1)(s+2)^2} \quad \text{Find } y(t) ??$$

Solution:

$$\frac{2}{(s+1)(s+2)^2} = \frac{A}{(s+1)} + \frac{B}{(s+2)} + \frac{C}{(s+2)^2}$$

$$2 = A(s+2)^2 + B(s+1)(s+2) + C(s+1)$$

$$s = -2 \rightarrow C(-1) = 2 \rightarrow C = -2$$

$$s = -1 \rightarrow A = 2$$

$$s = 0 \rightarrow B = -2$$

2]

$$\int \frac{2}{(s+1)(s+2)^2} = \int \frac{2}{(s+1)} + \int \frac{-2}{(s+2)} + \int \frac{-2}{(s+2)^2}$$

$$y(t) = 2e^{-t} - 2e^{-2t} - 2te^{-2t}$$

steady state value: $y_{ss} = \lim_{t \rightarrow \infty} y(t) = \lim_{s \rightarrow 0} s y(s) = 1$

1- لا يتأخذ النهاية لان دالة التحويل ليست دالة في النهاية

2- لا يتأخذ النهاية لان دالة التحويل ليست دالة في النهاية

example: $y(s) = \left(\frac{2}{s+1} - \frac{1}{s+2} \right) y$ $\rightarrow$ دالة

$$y_{ss} = \lim_{s \rightarrow 0} s y(s)$$

$$= \lim_{s \rightarrow 0} s \left(\frac{2}{s+1} - \frac{1}{s+2} \right) y$$

$$y_{ss} = 0$$

► Subject :

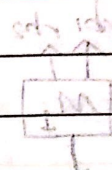
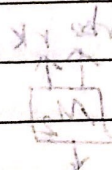
- Find the steady-state value to the system response.

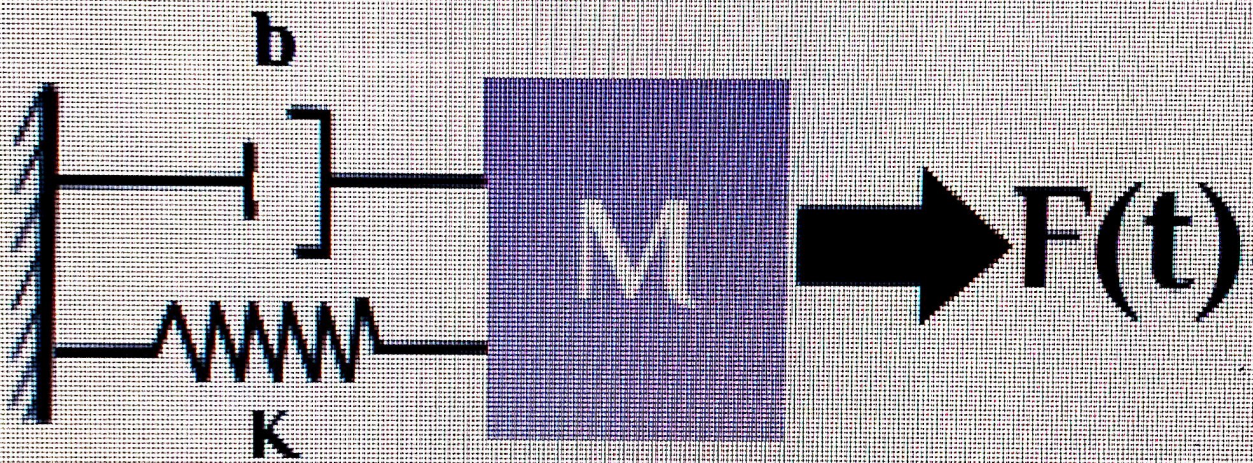
$$y(s) = \frac{1}{s(s+1)}$$

$$y_{ss} = \lim_{s \rightarrow 0} s y(s)$$

$$y_{ss} = \cancel{(s)} \frac{1}{(\cancel{s}(s+1))} = \frac{1}{s+1} \rightarrow \text{at } s=0$$

$$y_{ss} = \frac{1}{0+1} = 1$$





Transfer function

$$T(s) = \frac{Y(s)}{R(s)} \quad \begin{array}{l} \text{laplace output} \\ \text{laplace input} \end{array}$$

example: Find the transfer function of system below.

solution:

$$\Sigma F = ma = m\ddot{x}$$

input $\rightarrow f(t)$

$$F(t) = m\ddot{x} + kx + b\dot{x} \rightarrow \text{بالطرفين}$$

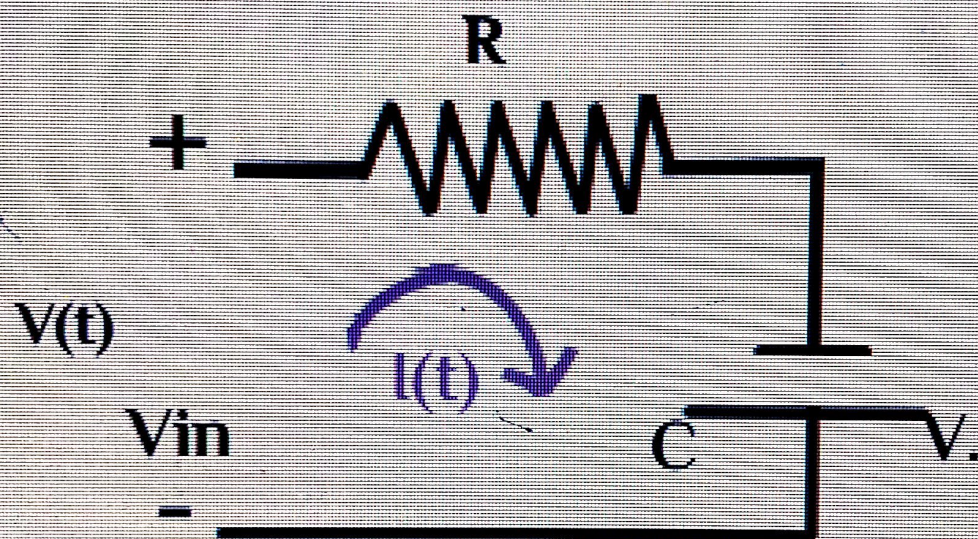
output $\rightarrow x(t)$

$$F(s) = ms^2X(s) + kX(s) + sbX(s) \rightarrow \text{كل طرفه بالس}$$

$$T(s) = \frac{X(s)}{f(s)}$$

$$f(s) = X(s)(ms^2 + k + bs)$$

$$\frac{X(s)}{f(s)} = \frac{1}{ms^2 + k + bs}$$



Find the transfer Function of system below.

input $\rightarrow V(t)$

output $\rightarrow V_o$

$$T(s) = \frac{V_o(s)}{V_{in}(s)}$$

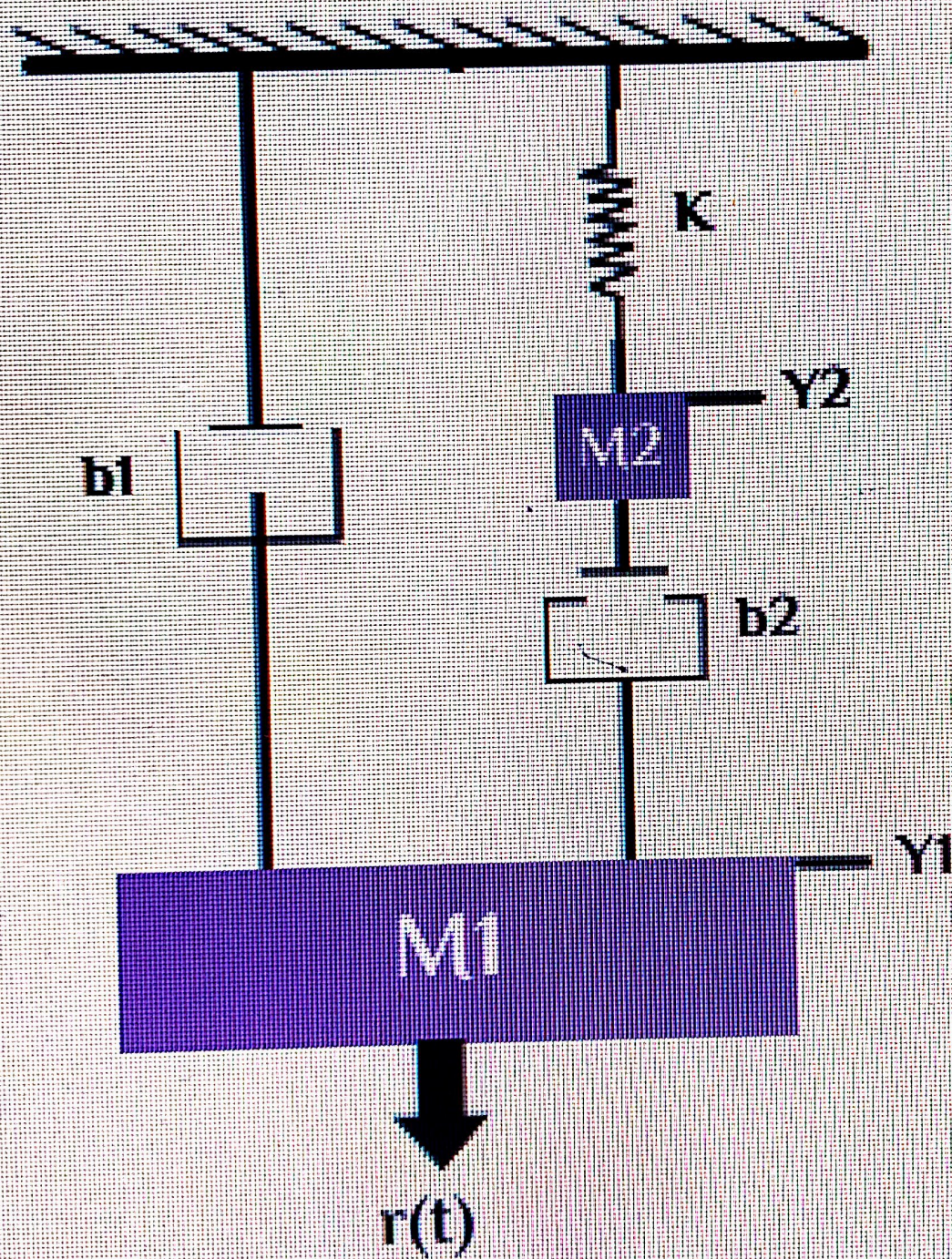
$$V_{in} = V_R + V_o \rightarrow V_o \text{ (capacitor)} \rightarrow I = C \dot{V}$$

$$= IR + V_o \rightarrow V_o = I R \text{ (resistor)}$$

$$V_{in}(t) = RC \dot{V}_o + V_o \rightarrow V_{in}(s) = RCS V_o(s) + V_o(s) \rightarrow V_o(s) \text{ (output)}$$

$$V_{in}(s) = V_o(s) (RCS + 1)$$

$$\frac{V_o(s)}{V_{in}(s)} = \frac{1}{RCS + 1}$$

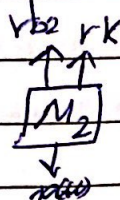
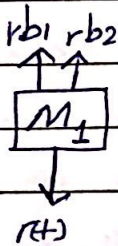


- Find the $T(s)$ of system below

1- input $\rightarrow r(t)$

2- output $\rightarrow y_1, y_2$ we have two outputs, Two transfer function.

Solution:



1] $r(t) = m \ddot{y} = m a$

$r(t) = m \ddot{y} + b_1 \dot{y}_1 + b_2 \dot{y}_2$

$r(t) = m \ddot{y} + b_1 \dot{y}_1 + b_2 (\dot{y}_1 - \dot{y}_2)$

2] $r(t) = m_2 \ddot{y}_2 + k y_2 + b_2 (\dot{y}_2 - \dot{y}_1)$

3] R, y_1, y_2 معادلات بين و متغيرات

laplace متحول y_2, y_1 الى معادلات

4] 1 $m_1 \ddot{y}_1 + b_1 \dot{y}_1 + b_2 (\dot{y}_1 - \dot{y}_2) = r(t)$

$m_1 s^2 y_1(s) + b_1 s y_1(s) + b_2 s (y_1(s) - y_2(s)) = r(s)$

$m_1 s^2 y_1(s) + b_1 s y_1(s) + b_2 s y_1(s) - b_2 s y_2(s) = r(s)$

$y_1(s) (m_1 s^2 + b_1 s + b_2 s) = r(s) + b_2 s y_2$

$y_1(s) = \frac{r(s) + b_2 s y_2}{m_1 s^2 + b_1 s + b_2 s}$

5] 2 $m_2 \ddot{y}_2 + b_2 (\dot{y}_2 - \dot{y}_1) + k y_2 = 0$

$m_2 s^2 y_2(s) + b_2 s (y_2(s) - y_1(s)) + k y_2(s) = 0$

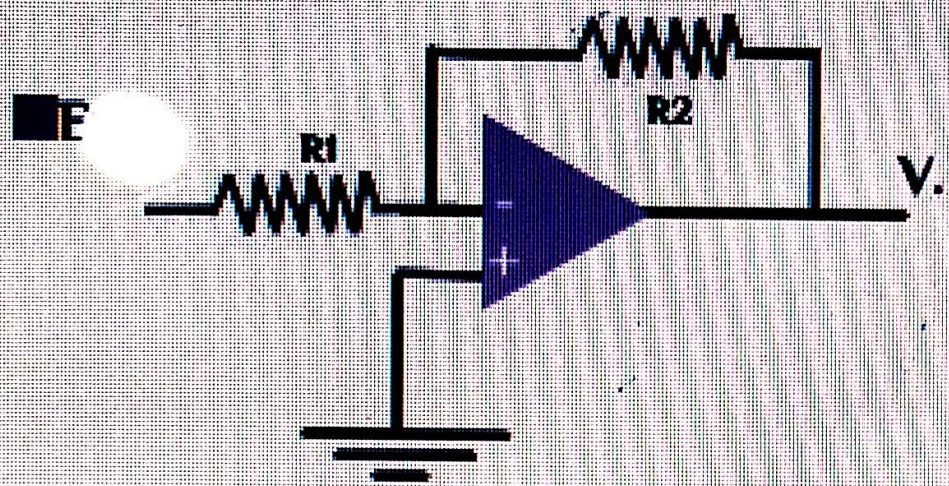
$y_2 (m_2 s^2 + k + b_2 s) = b_2 s y_1(s)$

$y_2 = \frac{b_2 s y_1(s)}{m_2 s^2 + k + b_2 s}$

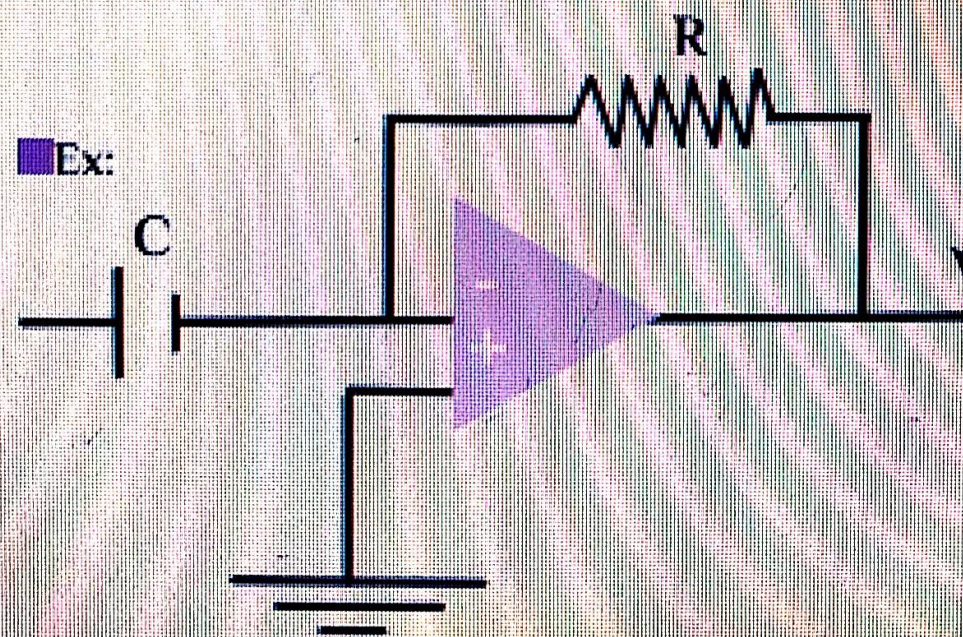
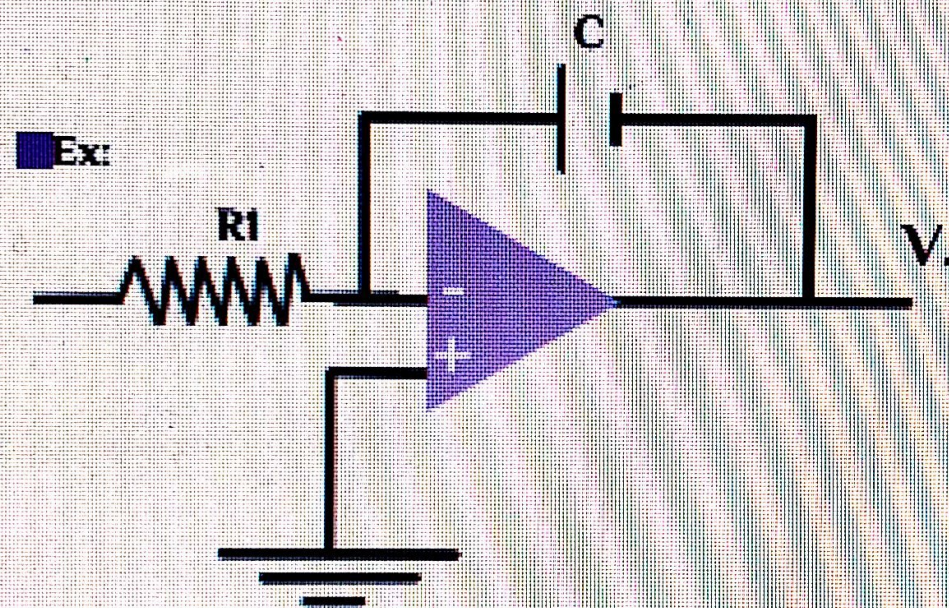
$\frac{y(s)}{r(s)}$

$m_2 s^2 + k + b_2 s$

$(m_1 s^2 + b_1 s) (m_2 s^2 + k + b_2 s)$
 $= b_2^2 s^2$



propotional controlle



► Subject :

Operation Amplifier:

$$\frac{V_o}{V_{in}} = - \frac{\text{feedback}}{\text{input}}$$

resistance $\rightarrow Z_R = R$

capacitor $\rightarrow Z_C = \frac{1}{Cs}$

inductor $\rightarrow Z_L = s$

example:

Find the operation Amplifier.

solution:

$$\frac{Z_f}{Z_{in}} = - \frac{R_2}{R_1}$$

$$\frac{Z_f}{Z_{in}} = - \frac{1}{Cs} \cdot \frac{1}{R_1}$$

$$\frac{Z_f}{Z_{in}} = - \frac{R}{\frac{1}{Cs}} = - Rcs$$

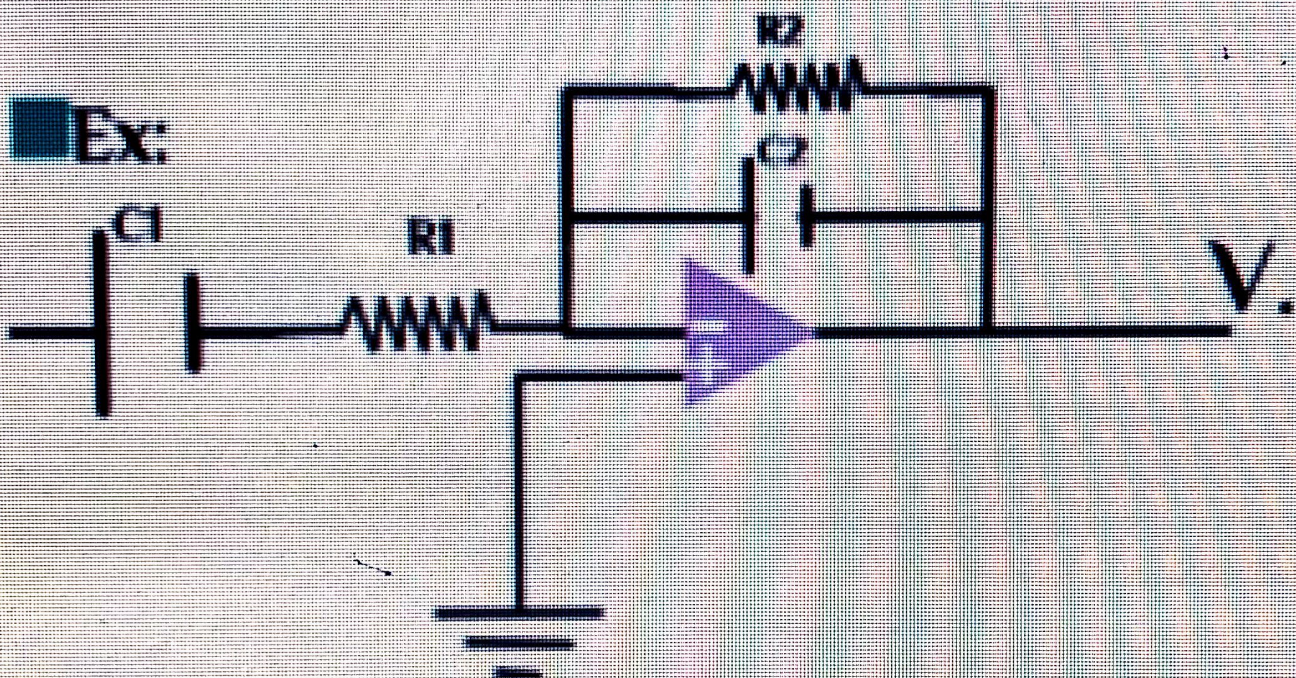
value 2 ← value 1

value 2 ← value 1

value 2 ← value 1

$$f_{TMV} = \dot{A}I + \ddot{A}T$$

(2) value 1 ← value 2



- هاء الى حلة رجي تاليه وتطريه ربيكل ربيكل لجال

$$Z_F = \frac{R \times \frac{1}{C_S}}{R + \frac{1}{C_S}} \quad \text{في طلكان Parallel (حامل الفيسل الجمع)}$$

$$\text{series (حامل الجمع)}$$

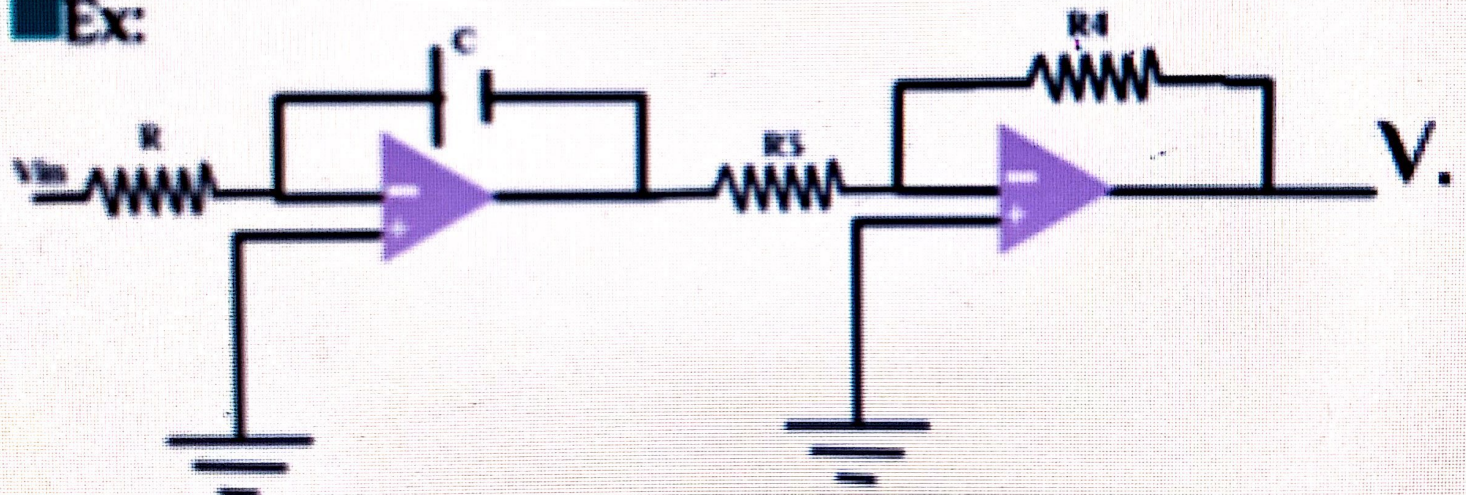
$$= \frac{\frac{R}{C_S}}{\frac{R C_S + 1}{C_S}} = \frac{R}{R C_S + 1}$$

$$Z_{input} = \frac{1}{C_S} + R_1 = \frac{R C_S + 1}{C_S}$$

$$\frac{Z_F}{Z_{in}} = \frac{\frac{-R_2}{R_2 C_2 S + 1}}{\frac{R_1 C_1 S + 1}{C_1 S}} = \frac{-R_2 C_1 S}{(R_1 C_1 S + 1)(R_2 C_2 S + 1)}$$

S T C₁ S, R S N O T E

■ Ex:



Subject :

لما يكون في انظر op am قريب
النتائج بيننا الجيد.

$$\frac{Z_F}{Z_{inpt}} * \frac{Z_F}{Z_{inpt}} = \frac{-1}{s} * \frac{-R_1}{R_3} = \frac{R_1}{s R_1 R_3}$$

DC motor $\begin{cases} \rightarrow \text{stator} \\ \rightarrow \text{rotor} \end{cases}$

Amplifier $\rightarrow$ controller

DC motor $\rightarrow$ Actuator.

Armature (Rotor) $\rightarrow$ L_a

stator field $\rightarrow$ I_f

$$J\ddot{\theta} + b\dot{\theta} = km I_f$$

Field controlled DC-motor $\left(\frac{\theta(s)}{I_f(s)} \right)$

$$J\ddot{\theta} + b\dot{\theta} = km I_f \rightarrow$$

$$J s^2 \theta(s) + b s \theta(s) = km I_f(s)$$

$$\theta(s) (J s^2 + b s) = km I_f(s)$$

$$\frac{\theta(s)}{I_f(s)} = \frac{km}{J s^2 + b s}$$