

Calculus

$\int_0^{\pi} x^2 \sin(x) dx$ by parts:

$$\left(-x^2 \cos x\right)_0^{\pi} + 2 \int_0^{\pi} x \cos x dx = \pi^2 - 4$$

Linear Algebra

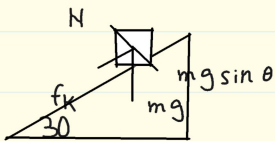
Eigenvalues of $A = \begin{bmatrix} 3 & 1 \\ 0 & 2 \end{bmatrix}$:

$$\det(A - \lambda I) = (3 - \lambda)(2 - \lambda) = 0$$

$$\lambda_1 = 3 \rightarrow v_1 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}, \quad \lambda_2 = 2 \rightarrow v_2 = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

Free Body Diagram

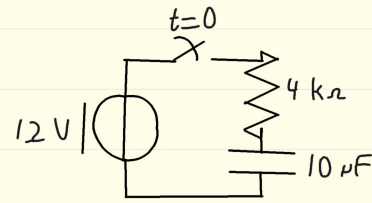
5 kg block on 30 degree incline, $\mu_k = 0.2$:



$$a = g(\sin \theta - \mu_k \cos \theta) = 3.2 \text{ m/s}^2$$

Circuit Analysis

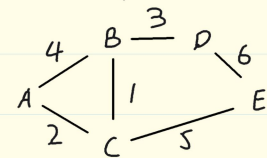
RC circuit find $V_C(t)$:



$$\tau = RC = 0.04 \text{ s}, \quad V_C(t) = 12(1 - e^{-t/0.04}) \text{ V}$$

Graph Theory

Shortest path from A to E:



$$A \rightarrow C \rightarrow E: \text{cost} = 2 + 5 = 7$$

Chemistry (ICE Table)

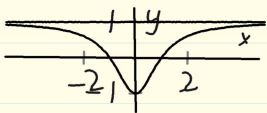
$\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$ find equilibrium:

	H_2	I_2	HI
Initial	0.50	0.40	0
Change	-x	-x	+2x
Equil.	0.50-x	0.40-x	2x

$$K_{eq} = \frac{(2x)^2}{(0.50-x)(0.40-x)}$$

Function Graphing

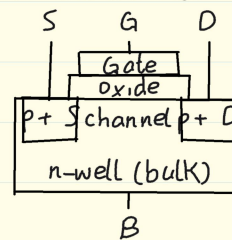
$$f(x) = \frac{x^2 - 1}{x^2 + 1}$$



Asymptote $y = 1$, zeros at $x = \pm 1$

MOSFET Cross-Section

PMOS transistor structure:



Electromagnetic Theory

Faraday's law says $\nabla \times E = -\partial B / \partial t$ so a changing magnetic field induces an electric field. For a coil with N turns, the induced EMF is $\mathcal{E} = -N \frac{d\Phi}{dt}$. You get the flux from $\Phi^B = \int B \cdot dA$ over the loop area and differentiate with respect to time. This principle drives everything from transformers to electric guitars. The full set of Maxwell's equations in differential form:

$$\nabla \cdot E = \frac{\rho}{\epsilon_0} \quad \nabla \cdot B = 0 \quad \nabla \times E = -\frac{\partial B}{\partial t} \quad \nabla \times B = \mu_0 J + \mu_0 \epsilon_0 \frac{\partial E}{\partial t}$$