

# פיזיקה 1 מ

פרק 11 - הסבר יותר מעמיק על גרדיאנט ורוטור (למי שמעוניין)

תוכן העניינים

1. אופרטור הנאבלה ..... 1

## אופרטור נאבלה:

רקע:

$$\vec{\nabla} = \left( \hat{x} \frac{\partial}{\partial x} + \hat{y} \frac{\partial}{\partial y} + \hat{z} \frac{\partial}{\partial z} \right) \equiv \left( \frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z} \right)$$

כדוריות	גליליות	קרטזיות	
$\frac{\partial f}{\partial r} \hat{r} + \frac{1}{r \sin \varphi} \frac{\partial f}{\partial \theta} \hat{\theta} + \frac{1}{r} \frac{\partial f}{\partial \varphi} \hat{z}$	$\frac{\partial f}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial f}{\partial \theta} \hat{\theta} + \frac{\partial f}{\partial z} \hat{z}$	$\frac{\partial f}{\partial x} \hat{x} + \frac{\partial f}{\partial y} \hat{y} + \frac{\partial f}{\partial z} \hat{z}$	grad $\vec{\nabla} f$
$\frac{1}{r^2} \frac{\partial(r^2 F_r)}{\partial r} + \frac{1}{r \sin \varphi} \frac{\partial F_\theta}{\partial \theta} + \frac{1}{r \sin \varphi} \frac{\partial}{\partial \varphi} (A_\varphi \sin \varphi)$	$\frac{1}{r} \frac{\partial(r F_r)}{\partial r} + \frac{1}{r} \frac{\partial F_\theta}{\partial \theta} + \frac{\partial F_z}{\partial z}$	$\frac{\partial F_x}{\partial x} + \frac{\partial F_y}{\partial y} + \frac{\partial F_z}{\partial z}$	div $\vec{\nabla} \cdot \vec{F}$
$\frac{1}{r \sin \theta} \left( \frac{\partial}{\partial \theta} (F_\theta \sin \varphi) - \frac{\partial F_\varphi}{\partial \theta} \right) \hat{r} + \frac{1}{r} \left( \frac{\partial}{\partial r} (r F_\varphi) - \frac{\partial F_r}{\partial \varphi} \right) \hat{\theta}$ $+ \frac{1}{r} \left( \frac{1}{\sin \theta} \frac{\partial F_r}{\partial \theta} - \frac{\partial}{\partial r} (r \cdot F_\theta) \right) \hat{\varphi}$	$\left( \frac{1}{r} \frac{\partial F_z}{\partial \theta} - \frac{\partial F_\theta}{\partial z} \right) \hat{r} + \left( \frac{\partial F_r}{\partial z} - \frac{\partial F_z}{\partial r} \right) \hat{\theta}$ $+ \frac{1}{r} \left( \frac{\partial(r F_\theta)}{\partial r} - \frac{\partial F_r}{\partial \theta} \right) \hat{z}$	$\left( \frac{\partial F_z}{\partial y} - \frac{\partial F_y}{\partial z} \right) \hat{x} - \left( \frac{\partial F_z}{\partial x} - \frac{\partial F_x}{\partial z} \right) \hat{y}$ $+ \left( \frac{\partial F_y}{\partial x} - \frac{\partial F_x}{\partial y} \right) \hat{z}$	Rot/curl $\vec{\nabla} \times \vec{F}$

זהויות:

$$\begin{aligned} \vec{\nabla}(f + g) &= \vec{\nabla}f + \vec{\nabla}g \\ \vec{\nabla}(\vec{A} + \vec{B}) &= (\vec{\nabla} \cdot \vec{A}) + (\vec{\nabla} \cdot \vec{B}) \\ \vec{\nabla} \times (\vec{A} + \vec{B}) &= (\vec{\nabla} \times \vec{A}) + (\vec{\nabla} \times \vec{B}) \\ \vec{\nabla}(\vec{A} \cdot \vec{B}) &= \vec{A} \times (\vec{\nabla} \times \vec{B}) + \vec{B} \times (\vec{\nabla} \times \vec{A}) + (\vec{A} \cdot \vec{\nabla}) \vec{B} + (\vec{B} \cdot \vec{\nabla}) \vec{A} \\ \vec{\nabla}(f \cdot g) &= (\vec{\nabla}f) \cdot g + (\vec{\nabla}g) \cdot f \\ \vec{\nabla}(f \cdot \vec{A}) &= f(\vec{\nabla} \cdot \vec{A}) + \vec{A} \cdot (\vec{\nabla}f) \end{aligned}$$