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 **Buona fortuna per l'esame!**

NOME:  
 COGNOME:  
 MATRICOLA:

<div>■ <b>FONDAMENTALI</b></div> <div>· <b>Teorema (divergenza)</b></div> $\int_{\Sigma} \mathbf{F} \cdot d\mathbf{\Sigma} = \int_{\tau} \nabla \cdot \mathbf{F} d\tau$ <div>· <b>Teorema (Stokes)</b></div> $\oint_{\gamma} \mathbf{F} \cdot d\mathbf{s} = \int_{\Sigma} \nabla \times \mathbf{F} d\mathbf{\Sigma}$ <div>· <b>Teorema (Gradiente)</b></div> $\phi_2 - \phi_1 = \int_{\gamma} \nabla \phi \cdot d\mathbf{s}$ <div>· <b>Flusso di un campo</b></div> $\Phi_{\Sigma}(\mathbf{E}) = \oint_{\Sigma} \mathbf{E} \cdot d\mathbf{\Sigma}$ <div>· <b>Equazioni di Maxwell</b> Nel vuoto:</div> $\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$ $\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$ $\nabla \cdot \mathbf{B} = 0$ $\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$ $\oint_{\Sigma} \mathbf{E} \cdot d\mathbf{\Sigma} = \frac{Q_{int}}{\varepsilon_0}$ $\oint_{\Gamma} \mathbf{E} \cdot d\mathbf{s} = -\frac{d\Phi(\mathbf{B})}{dt}$ $\oint_{\Sigma} \mathbf{B} \cdot d\mathbf{\Sigma} = 0$ $\oint_{\Gamma} \mathbf{B} \cdot d\mathbf{s} = \mu_0 I_{conc} + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$ <div>Nei mezzi:</div> $\nabla \cdot \mathbf{D} = \rho_{libere}$ $\nabla \times \mathbf{H} = \mathbf{J}_{C,lib} + \frac{\partial \mathbf{D}}{\partial t}$ $\oint_{\Sigma} \mathbf{D} \cdot d\mathbf{\Sigma} = Q_{int,lib}$ $\oint_{\Gamma} \mathbf{H} \cdot d\mathbf{s} = I_{conc,lib} + \frac{d\Phi_D}{dt}$ <div>· <b>Discontinuità dei campi</b> Generali</div> $\Delta B_{\perp} = 0$ $\Delta E_{\parallel} = 0$ $\Delta D_{\perp} = \sigma_L$ $\Delta E_{\perp} = \frac{\sigma}{\varepsilon_0}$ $\Delta H_{\parallel} =  \mathbf{K}_c \times \mathbf{u}_n $ <div>In ipotesi di linearità</div> $\frac{D_{1,\parallel}}{k_1} = \frac{D_{2,\parallel}}{k_2}$ <div>Se <math>\sigma_L = 0</math></div> $k_1 E_{1,\perp} = k_2 E_{2,\perp}$ <div>Rifrazione linee di B</div> $\frac{\tan(\theta_2)}{\tan(\theta_1)} = \frac{\mu_2}{\mu_1}$	<div>· <b>Potenziale scalare V</b></div> $V(\mathbf{r}) = \frac{U(\mathbf{r})}{q_0}$ $V(B) - V(A) = - \int_A^B \mathbf{E} \cdot d\mathbf{r}$ $\mathbf{E} = -\nabla V$ <div>· <b>Energia di E</b></div> $U = \frac{1}{2} \int_{\mathbb{R}^3} \rho(\mathbf{r}) V(\mathbf{r}) d\tau$ $U = \frac{1}{2} \varepsilon_0 \int_{\mathbb{R}^3} \mathbf{E}^2 d\tau$ <div>· <b>Equazione di Poisson</b></div> $\nabla^2 V = -\frac{\rho}{\varepsilon_0}$ <div>· <b>E e V di particolari distribuzioni</b> Carica puntiforme</div> $\mathbf{E} = \frac{q}{4\pi\varepsilon_0 r^2} \mathbf{u}_r$ $V = \frac{q}{4\pi\varepsilon_0 r}$ <div>Sfera carica uniformemente</div> $\mathbf{E}(r) = \begin{cases} \frac{Qr}{4\pi\varepsilon_0 R^3} = \frac{\rho r}{3\varepsilon_0} & \text{se } r < R \\ \frac{Q}{4\pi\varepsilon_0 R^2} & \text{se } r \geq R \end{cases}$ $V(r) = \begin{cases} \frac{\rho(3R^2 - r^2)}{6\varepsilon_0} & \text{se } r < R \\ \frac{Q}{4\pi\varepsilon_0 r} & \text{se } r \geq R \end{cases}$ <div>Guscio sferico carico uniformemente</div> $\mathbf{E}(r) = \begin{cases} 0 & \text{se } r < R \\ \frac{Q}{4\pi\varepsilon_0 R^2} & \text{se } r \geq R \end{cases}$ $V(r) = \begin{cases} \frac{Q}{4\pi\varepsilon_0 R} & \text{se } r < R \\ \frac{Q}{4\pi\varepsilon_0 r} & \text{se } r \geq R \end{cases}$ <div>Filo infinito con carica uniforme <math>\lambda</math></div> $\mathbf{E}(r) = \frac{\lambda}{2\pi\varepsilon_0 r} \mathbf{u}_r$ $V(r) = \frac{\lambda}{2\pi\varepsilon} \ln\left(\frac{r_0}{r}\right)$ <div>Piano <math>\Sigma</math> infinito con carica uniforme</div> $\mathbf{E} = \frac{\sigma}{2\varepsilon_0} \mathbf{u}_n$ $V(x) = \frac{\sigma}{2\varepsilon_0} (x - x_0)$ <div>Anello con carica uniforme (sull'asse)</div> $\mathbf{E}(x) = \frac{\lambda R x}{2\varepsilon_0 (x^2 + R^2)^{3/2}} \mathbf{u}_x$ $V(x) = \frac{\lambda R}{2\varepsilon_0 \sqrt{x^2 + R^2}}$ <div>Disco carico uniformemente</div> $\mathbf{E}(x) = \frac{\sigma}{2\varepsilon_0} \left(1 - \frac{1}{\sqrt{1 + \frac{R^2}{x^2}}}\right) \mathbf{u}_x$ $V(x) = \frac{\sigma}{2\varepsilon_0} (\sqrt{x^2 + R^2} - x)$ <div>Disco carico uniformemente (<math>x \gg R</math>)</div> $\mathbf{E}(x) = \frac{\sigma}{2\varepsilon_0} \frac{R^2}{x^2} \mathbf{u}_x$ $V(x) = \frac{\sigma}{4\varepsilon_0} \frac{R^2}{x}$ <div>Guscio cilindrico uniformemente carico</div> $\mathbf{E}(r) = \begin{cases} 0 & \text{se } r < R \\ \frac{Q}{2\pi\varepsilon_0 h r} & \text{se } r \geq R \end{cases}$ $V(r) = \begin{cases} 0 & \text{se } r < R \\ \frac{Q}{2\pi\varepsilon_0 h} \ln\left(\frac{r}{R}\right) & \text{se } r \geq R \end{cases}$
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<div>■ <b>ELETTROSTATICA</b></div> <div>· <b>Forza di Coulomb</b></div> $\mathbf{F} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2} \mathbf{u}_{1,2}$ <div>· <b>Definizione campo elettrico</b></div> $\mathbf{E} = \frac{\mathbf{F}(\mathbf{r}_0)}{q_0}$ <div>· <b>En. potenziale due cariche</b></div> $U = \frac{q_1 q_2}{4\pi\varepsilon_0 r_{1,2}} + c$	<div>(27)</div>
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<div>· <b>Conduttori in equilibrio</b> All'interno</div> <div>– il campo è nullo</div> $\mathbf{E} = 0$ <div>– il potenziale è costante</div> $\Delta V = 0$ <div>Le cariche si distribuiscono sempre su superfici, mai all'interno</div> <div>· <b>Pressione elettrostatica</b></div> $\mathbf{p} = \frac{d\mathbf{F}}{d\Sigma} = \frac{\sigma^2}{2\varepsilon_0} \mathbf{u}_n = \frac{1}{2} \varepsilon_0 \mathbf{E}^2$ <div>· <b>Capacità</b></div> $C = \frac{Q}{\Delta V}$ <div>Il più delle volte c'è induzione completa e C dipende dalla configurazione geometrica.</div> <div>· <b>Condensatori</b> Piano</div> $C = \frac{\varepsilon_0 \Sigma}{d}$ <div>Sferico</div> $C = 4\pi\varepsilon_0 \frac{Rr}{R-r}$ <div>Cilindrico</div> $C = \frac{2\pi\varepsilon_0 h}{\ln \frac{R}{r}}$ <div>In serie</div> $C_{eq} = \left( \sum_{i=1}^n \frac{1}{C_i} \right)^{-1}$ <div>In parallelo</div> $C_{eq} = \sum_{i=1}^n C_i$ <div>Con dielettrico</div> $C_{diel} = k_e C_0$ <div>Energia interna del condensatore</div> $U = \frac{Q^2}{2C} = \frac{1}{2} C V^2 = \frac{1}{2} Q V$ <div>Differenziale circuito RC</div> $RQ'(t) + \frac{Q(t)}{C} = V$ <div>Carica</div> $Q(t) = Q_0 (1 - e^{-\frac{t}{RC}})$ <div>Scarica</div> $Q(t) = Q_0 e^{-\frac{t}{RC}}$ <div>· <b>Condensatore pieno</b> Condensatore riempito di materiale di resistività <math>\rho</math></div> $RC = \varepsilon_0 \rho$ <div>· <b>Forza fra le armature</b></div> $F = \frac{Q^2}{2} \partial_x \left( \frac{1}{C} \right)$ <div>Condensatore piano</div> $F = \frac{Q\sigma}{2\varepsilon_0} = \frac{Q^2}{2\varepsilon_0 \Sigma}$	<div>(28)</div> <div>(29)</div> <div>(30)</div> <div>(31)</div> <div>(32)</div> <div>(33)</div> <div>(34)</div> <div>(35)</div> <div>(36)</div> <div>(37)</div> <div>(38)</div> <div>(39)</div> <div>(40)</div> <div>(41)</div> <div>(42)</div> <div>(43)</div> <div>(44)</div> <div>(45)</div> <div>(46)</div> <div>(47)</div> <div>(48)</div> <div>(49)</div> <div>(50)</div> <div>(51)</div>
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■ **CONDUTTORI**

<div>· <b>Campo elettrico E generato</b></div> $\mathbf{E} = \frac{qd \left( 2 \cos(\theta) \mathbf{u}_r + \sin(\theta) \mathbf{u}_{\theta} \right)}{4\pi\varepsilon r^3}$ <div>· <b>Momento torcente</b></div> $\mathbf{M} = \mathbf{a} \times q\mathbf{E}(x, y, z)$ <div>Se E uniforme</div> $\mathbf{M} = \mathbf{p} \times \mathbf{E}$ <div>· <b>Lavoro per ruotarlo</b></div> $W = \int_{\theta_i}^{\theta_f} M d\theta$ <div>Se E uniforme</div> $W = pE [\cos(\theta_i) - \cos(\theta_f)]$ <div>· <b>Frequenza dipolo oscillante</b> Se E costante e uniforme</div> $\nu = \frac{1}{2\pi} \sqrt{\frac{pE}{I}}$ <div>· <b>Energia del dipolo</b></div> $U = -\mathbf{p} \cdot \mathbf{E}$ <div>· <b>Forza agente sul dipolo</b></div> $\mathbf{F} = \nabla(\mathbf{p} \cdot \mathbf{E})$ <div>· <b>Energia pot. tra due dipoli</b></div> $U = \frac{[\mathbf{p}_1 \cdot \mathbf{p}_2 - 3(\mathbf{p}_1 \mathbf{u}_r)(\mathbf{p}_2 \cdot \mathbf{u}_r)]}{4\pi\varepsilon_0 r^3}$ <div>· <b>Forza tra dipoli</b> Dipoli concordi = F repulsiva</div> $\mathbf{F} = \frac{3p_1 p_2}{4\pi\varepsilon_0 r^4} \mathbf{u}_r$	<div>(71)</div> <div>(72)</div> <div>(73)</div> <div>(74)</div> <div>(75)</div> <div>(76)</div> <div>(77)</div> <div>(78)</div> <div>(79)</div> <div>(80)</div>
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<div>■ <b>DIELETTRICI</b></div> <div>· <b>Campo elettrico in un dielettrico</b></div> $\mathbf{E}_k = \frac{\mathbf{E}_0}{k}$ <div>· <b>Vettore P polarizzazione</b></div> $\mathbf{P} = \frac{dp}{d\tau}$ <div>· <b>Dielettrici lineari</b></div> $\mathbf{P} = \varepsilon_0 \chi_E \mathbf{E}_k = \varepsilon_0 (k - 1) \mathbf{E}_k$ <div>· <b>Dens. superficiale di q polarizzata</b></div> $\sigma_p = \mathbf{P} \cdot \mathbf{u}_n = \frac{k-1}{k} \sigma_l$ <div>· <b>Dens. volumetrica di q polarizzata</b></div> $\rho_p = -\nabla \cdot \mathbf{P}$ <div>· <b>Spostamento elettrico</b></div> $\mathbf{D} = \varepsilon_0 \mathbf{E}_k + \mathbf{P} = \varepsilon_0 k \mathbf{E}_k = \varepsilon_0 \mathbf{E}_0$	<div>(81)</div> <div>(82)</div> <div>(83)</div> <div>(84)</div> <div>(85)</div> <div>(86)</div>
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<div>■ <b>CORRENTI</b></div> <div>· <b>Lavoro del generatore</b></div> $W_{gen} = \int_{t_1}^{t_2} V dq(t) = 2U_E$ <div>· <b>Densità di corrente</b></div> $\mathbf{J} = nq\mathbf{v} = \frac{Nq\mathbf{v}}{\tau}$ <div>· <b>Intensità di corrente</b></div> $I = \frac{dq(t)}{dt} = \int_{\Sigma} \mathbf{J} \cdot d\mathbf{\Sigma}$ <div>· <b>Leggi di Ohm</b></div> $V = RI$ $R = \int_{\Gamma} \frac{\rho}{\Sigma} dl$ $\mathbf{E} = \rho \mathbf{J}$ $\rho = \frac{1}{\sigma}$	<div>(87)</div> <div>(88)</div> <div>(89)</div> <div>(90)</div> <div>(91)</div> <div>(92)</div> <div>(93)</div>
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· <b>Effetto Joule</b>	
<span><span>    ⟨<!-- ⟨ -->  P  R   ⟩<!-- ⟩ --> =    V  0    2 R     {\displaystyle \langle P_{R}\rangle ={\frac {V_{0}}{2R}}}  </span></span>	(180)
· <b>Potenza media totale</b>	
<span><span>    ⟨<!-- ⟨ --> P ⟩<!-- ⟩ --> =    V  0   I  0    2    cos ⁡<!-- ⁡ --> ( ϕ<!-- ϕ --> )   {\displaystyle \langle P\rangle ={\frac {V_{0}I_{0}}{2}}\cos(\phi )}  </span></span>	(181)
· <b>V e I efficace</b>	
<span><span>     V  e f f   =   √<!-- √ --> 2  2    V  0              I  e f f   =   √<!-- √ --> 2  2    I  0     {\displaystyle V_{eff}={\frac {\sqrt {2}}{2}}V_{0}\quad I_{eff}={\frac {\sqrt {2}}{2}}I_{0}}  </span></span>	(182)

#### ■ CAMPO EM e OTTICA

· <b>Campi in un’onda EM</b> (Nel vuoto <i>v</i> = <i>c</i> )	
<span><span>    E ( x , t ) =  E  0    cos ⁡<!-- ⁡ --> ( k x −<!-- − --> ω<!-- ω --> t )   {\displaystyle E(x,t)=E_{0}\cos(kx-\omega t)}  </span></span>	(183)
<span><span>    B ( x , t ) =    E  0    v    cos ⁡<!-- ⁡ --> ( k x −<!-- − --> ω<!-- ω --> t )   {\displaystyle B(x,t)={\frac {E_{0}}{v}}\cos(kx-\omega t)}  </span></span>	(184)
<span><span>    ω<!-- ω --> = k v     k =    2 π<!-- π -->   λ<!-- λ -->        λ<!-- λ --> =    v ν<!-- ν -->     {\displaystyle \omega =kv\quad k={\frac {2\pi }{\lambda }}\quad \lambda ={\frac {v}{\nu }}}  </span></span>	
· <b>Vettore di Poynting</b>	
<span><span>     S   =    1  μ<!-- μ -->  0      E ×<!-- × --> B   {\displaystyle {\bold {S}}={\frac {1}{\mu _{0}}}{\bold {E}}\times {\bold {B}}}  </span></span>	(185)
· <b>Intensità media onda</b>	
<span><span>    I = ⟨<!-- ⟨ --> S ⟩<!-- ⟩ --> = ⟨<!-- ⟨ -->  E  2    ε<!-- ε --> v   ⟩<!-- ⟩ -->   {\displaystyle I=\langle S\rangle =\langle E^{2}\varepsilon v\rangle }  </span></span>	(186)
· <b>Potenza</b>	
<span><span>    P = I Σ<!-- Σ -->   {\displaystyle P=I\Sigma }  </span></span>	(187)
L’intensità varia in base alla scelta di Σ	
· <b>Equazioni di continuità</b> Teorema di Poynting	
<span><span>    ∇<!-- ∇ --> ⋅<!-- ⋅ --> S + E ⋅<!-- ⋅ -->   j  →<!-- → -->    +    ∂<!-- ∂ --> u  ∂<!-- ∂ --> t    = 0   {\displaystyle \nabla \cdot {\bold {S}}+{\bold {E}}\cdot {\bold {j}}+{\frac {\partial u}{\partial t}}=0}  </span></span>	(188)
Conservazione della carica	
<span><span>    ∇<!-- ∇ --> ⋅<!-- ⋅ -->   j  →<!-- → -->    +    ∂<!-- ∂ --> ρ<!-- ρ -->  ∂<!-- ∂ --> t    = 0   {\displaystyle \nabla \cdot {\bold {j}}+{\frac {\partial \rho }{\partial t}}=0}  </span></span>	(189)
· <b>Densità di en. campo EM</b>	
<span><span>     u  E M   =   1 2    ( E ⋅<!-- ⋅ --> D + B ⋅<!-- ⋅ --> H )   {\displaystyle u_{EM}={\frac {1}{2}}({\bold {E}}\cdot {\bold {D}}+{\bold {B}}\cdot {\bold {H}})}  </span></span>	(190)
<span><span>     U  E M   =  ∫<!-- ∫ -->  R  3      u  E M    d τ<!-- τ -->   {\displaystyle U_{EM}=\int _{\mathbb {R} ^{3}}u_{EM}\mathrm {d} \tau }  </span></span>	(191)
· <b>Densità di quantità di moto</b>	
<span><span>     g   =    S  c  2      {\displaystyle {\bold {g}}={\frac {\bold {S}}{c^{2}}}}  </span></span>	(192)
· <b>Effetto Doppler</b>	
<span><span>     ν<!-- ν --> ′   = ν<!-- ν -->    v −<!-- − -->  v  o s s     v −<!-- − -->  v  s o r g      {\displaystyle \nu '=\nu {\frac {v-v_{oss}}{v-v_{sorg}}}}  </span></span>	(193)
· <b>Oscillazione del dipolo</b>	
<span><span>    I ( r , θ<!-- θ --> ) =    I  0    r  2     sin  2   ⁡<!-- ⁡ --> ( θ<!-- θ --> )   {\displaystyle I(r,\theta )={\frac {I_{0}}{r^{2}}}\sin ^{2}(\theta )}  </span></span>	(194)
<span><span>    P =  ∫<!-- ∫ -->  ∫<!-- ∫ -->    I ( r , θ<!-- θ --> ) d r d θ<!-- θ --> =   8 3    π<!-- π -->  I  0     {\displaystyle P=\int \int I(r,\theta )\mathrm {d} r\mathrm {d} \theta ={\frac {8}{3}}\pi I_{0}}  </span></span>	(195)
· <b>Velocità dell’onda</b>	
<span><span>     v  2   =    1  k  e   ε<!-- ε -->  0    k  m    μ<!-- μ -->  0     {\displaystyle v^{2}={\frac {1}{k_{e}\varepsilon _{0}k_{m}\mu _{0}}}}  </span></span>	(196)
<span><span>     c  2   =    1  ε<!-- ε -->  0    μ<!-- μ -->  0     {\displaystyle c^{2}={\frac {1}{\varepsilon _{0}\mu _{0}}}}  </span></span>	(197)

#### ■ UNITÀ DI MISURA

<span><span>    H =    W b A    = T  m  2   =    m  2    k g   A  2    s  2      {\displaystyle H={\frac {Wb}{A}}=Tm^{2}={\frac {m^{2}kg}{A^{2}s^{2}}}}  </span></span>	(255)
<span><span>    Ω<!-- Ω --> =    V A    =    V  2   W    =    m  2    k g   A  2    s  3      {\displaystyle \Omega ={\frac {V}{A}}={\frac {V^{2}}{W}}={\frac {m^{2}kg}{A^{2}s^{3}}}}  </span></span>	(256)
<span><span>    T =    N A m    =    k g   A  s  2      {\displaystyle T={\frac {N}{Am}}={\frac {kg}{As^{2}}}}  </span></span>	(257)
<span><span>    V =    J C    =    W A    =    m  2    k g   s  3    A     {\displaystyle V={\frac {J}{C}}={\frac {W}{A}}={\frac {m^{2}kg}{s^{3}A}}}  </span></span>	(258)
<span><span>    F =    C V    =    C  2   J    =    A  2    s  4    m  2    k g     {\displaystyle F={\frac {C}{V}}={\frac {C^{2}}{J}}={\frac {A^{2}s^{4}}{m^{2}kg}}}  </span></span>	(259)

#### ■ FISICA 1

· <b>Momento torcente</b>	
<span><span>    M =  r  ×<!-- × -->  F   = I α<!-- α -->   {\displaystyle M={\bold {r}}\times {\bold {F}}=I\alpha }  </span></span>	(260)

· <b>Indice di rifrazione</b>	
<span><span>    n =    c v    =    √<!-- √ -->  k  e    k  m      {\displaystyle n={\frac {c}{v}}={\sqrt {k_{e}k_{m}}}}  </span></span>	(198)

#### · Legge di Snell-Cartesio

<span><span>     n  1   sin ⁡<!-- ⁡ -->  θ<!-- θ -->  1   =  n  2   sin ⁡<!-- ⁡ -->  θ<!-- θ -->  2     {\displaystyle n_{1}\sin \theta _{1}=n_{2}\sin \theta _{2}}  </span></span>	(199)
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#### · Coefficienti di Fresnel

Definizione	
<span><span>     r  =    E  r   E  i                R =    P  r   P  i    =    I  r   I  i      {\displaystyle r={\frac {E_{r}}{E_{i}}}\quad R={\frac {P_{r}}{P_{i}}}={\frac {I_{r}}{I_{i}}}}  </span></span>	(200)

<span><span>     t =    E  t   E  i                T =    P  t   P  i    =    I  t   I  i      {\displaystyle t={\frac {E_{t}}{E_{i}}}\quad T={\frac {P_{t}}{P_{i}}}={\frac {I_{t}}{I_{i}}}}  </span></span>	(201)
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Raggio RIFLESSO polarizzato	
<span><span>     r  σ<!-- σ -->   =    sin ⁡<!-- ⁡ --> (  θ<!-- θ -->  t   −<!-- − -->  θ<!-- θ -->  i   )  sin ⁡<!-- ⁡ --> (  θ<!-- θ -->  t   +  θ<!-- θ -->  i   )      {\displaystyle r_{\sigma }={\frac {\sin(\theta _{t}-\theta _{i})}{\sin(\theta _{t}+\theta _{i})}}}  </span></span>	(202)

<span><span>     r  π<!-- π -->   =    tan ⁡<!-- ⁡ --> (  θ<!-- θ -->  t   −<!-- − -->  θ<!-- θ -->  i   )  tan ⁡<!-- ⁡ --> (  θ<!-- θ -->  t   +  θ<!-- θ -->  i   )      {\displaystyle r_{\pi }={\frac {\tan(\theta _{t}-\theta _{i})}{\tan(\theta _{t}+\theta _{i})}}}  </span></span>	(203)
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<span><span>     R  σ<!-- σ -->   =  r  σ<!-- σ -->   2              R  π<!-- π -->   =  r  π<!-- π -->   2     {\displaystyle R_{\sigma }=r_{\sigma }^{2}\quad R_{\pi }=r_{\pi }^{2}}  </span></span>	(204)
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Raggio TRASMESSO polarizzato	
<span><span>     t  σ<!-- σ -->   =    2  n  i   cos ⁡<!-- ⁡ -->  θ<!-- θ -->  i     n  i   cos ⁡<!-- ⁡ -->  θ<!-- θ -->  i   +  n  t   cos ⁡<!-- ⁡ -->  θ<!-- θ -->  t      {\displaystyle t_{\sigma }={\frac {2n_{i}\cos \theta _{i}}{n_{i}\cos \theta _{i}+n_{t}\cos \theta _{t}}}}  </span></span>	(205)

<span><span>     t  p   i   =    2  n  i   cos ⁡<!-- ⁡ -->  θ<!-- θ -->  i     n  i   cos ⁡<!-- ⁡ -->  θ<!-- θ -->  t   +  n  t   cos ⁡<!-- ⁡ -->  θ<!-- θ -->  i      {\displaystyle t_{p}i={\frac {2n_{i}\cos \theta _{i}}{n_{i}\cos \theta _{t}+n_{t}\cos \theta _{i}}}}  </span></span>	(206)
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<span><span>     T  σ<!-- σ -->   = 1 −<!-- − -->  R  σ<!-- σ -->             T  π<!-- π -->   = 1 −<!-- − -->  R  π<!-- π -->     {\displaystyle T_{\sigma }=1-R_{\sigma }\quad T_{\pi }=1-R_{\pi }}  </span></span>	(207)
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Luce NON polarizzata	
<span><span>    R =    1 2    (  R  σ<!-- σ -->   +  R  π<!-- π -->   )           T =    1 2    (  T  σ<!-- σ -->   +  T  π<!-- π -->   )   {\displaystyle R={\frac {1}{2}}(R_{\sigma }+R_{\pi })\quad T={\frac {1}{2}}(T_{\sigma }+T_{\pi })}  </span></span>	(208)

Incidenza normale (cos θ <sub>i</sub> ? cos θ <sub>t</sub> = 1)	
<span><span>    r =    n  i   −<!-- − -->  n  t     n  i   +  n  t      {\displaystyle r={\frac {n_{i}-n_{t}}{n_{i}+n_{t}}}}  </span></span>	(209)

<span><span>    R =    (    n  i   −<!-- − -->  n  t     n  i   +  n  t      )  2      {\displaystyle R=\left({\frac {n_{i}-n_{t}}{n_{i}+n_{t}}}\right)^{2}}  </span></span>	(210)
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<span><span>    t =    2  n  i     n  i   +  n  t      {\displaystyle t={\frac {2n_{i}}{n_{i}+n_{t}}}}  </span></span>	(211)
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<span><span>    T =    4  n  i    n  t     (  n  i   +  n  t   )  2      {\displaystyle T={\frac {4n_{i}n_{t}}{(n_{i}+n_{t})^{2}}}}  </span></span>	(212)
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Angolo di Brewster (il raggio riflesso non ha polar. parallela)

<span><span>     θ<!-- θ -->  i   +  θ<!-- θ -->  t   =    π<!-- π --> 2   →<!-- → -->  θ<!-- θ -->  B   =  θ<!-- θ -->  i   = arctan ⁡<!-- ⁡ -->   n  t   n  i      {\displaystyle \theta _{i}+\theta _{t}={\frac {\pi }{2}}\rightarrow \theta _{B}=\theta _{i}=\arctan {\frac {n_{t}}{n_{i}}}}  </span></span>	(213)
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<span><span>    R =    1 2    cos  2   ⁡<!-- ⁡ --> ( 2  θ<!-- θ -->  i   )   {\displaystyle R={\frac {1}{2}}\cos ^{2}(2\theta _{i})}  </span></span>	(214)
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<span><span>    T = 1 −<!-- − --> R   {\displaystyle T=1-R}  </span></span>	(215)
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#### · Pressione di radiazione

Superficie ASSORBENTE	
<span><span>    p =    I  i   v      {\displaystyle p={\frac {I_{i}}{v}}}  </span></span>	(216)

Superficie RIFLETTENTE	
<span><span>    p =    I  i   +  I  t   +  I  r   v      {\displaystyle p={\frac {I_{i}+I_{t}+I_{r}}{v}}}  </span></span>	(217)

#### · Rapporto di polarizzazione

<span><span>     β<!-- β -->  R   =    P  R   σ<!-- σ -->   −<!-- − -->  P  R   π<!-- π -->     P  R   σ<!-- σ -->   +  P  R   π<!-- π -->      {\displaystyle \beta _{R}={\frac {P_{R}^{\sigma }-P_{R}^{\pi }}{P_{R}^{\sigma }+P_{R}^{\pi }}}}}  </span></span>	(218)
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<span><span>     β<!-- β -->  T   =    P  T   σ<!-- σ -->   −<!-- − -->  P  T   π<!-- π -->     P  T   σ<!-- σ -->   +  P  T   π<!-- π -->      {\displaystyle \beta _{T}={\frac {P_{T}^{\sigma }-P_{T}^{\pi }}{P_{T}^{\sigma }+P_{T}^{\pi }}}}}  </span></span>	(219)
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#### ■ INTERFERENZA e DIFFRAZIO-NE

· <b>Lavoro</b>	
<span><span>    F = ∇<!-- ∇ --> W = −<!-- − --> ∇<!-- ∇ --> U   {\displaystyle F=\nabla W=-\nabla U}  </span></span>	(261)

· <b>Moto circolare unif. accelerato</b>	
<span><span>    v = ω<!-- ω --> r   {\displaystyle v=\omega r}  </span></span>	(262)

<span><span>    a =    v  2   r    =  ω<!-- ω -->  2   r   {\displaystyle a={\frac {v^{2}}{r}}=\omega ^{2}r}  </span></span>	(263)
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<span><span>    θ<!-- θ --> ( t ) = θ<!-- θ --> ( 0 ) + ω<!-- ω --> ( 0 ) t +   1 2    α<!-- α -->  t  2      {\displaystyle \theta (t)=\theta (0)+\omega (0)t+{\frac {1}{2}}\alpha t^{2}}  </span></span>	(264)
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#### · Moto armonico

Equazione differenziale	
<span><span>     x ′′<!-- ′′ -->   +  ω<!-- ω -->  2   x = 0   {\displaystyle x''+\omega ^{2}x=0}  </span></span>	(265)

Soluzione	
<span><span>    x ( t ) = A sin ⁡<!-- ⁡ --> ( ω<!-- ω --> t + ϕ<!-- ϕ --> )   {\displaystyle x(t)=A\sin(\omega t+\varphi )}  </span></span>	(266)

#### · Interferenza generica

Onda risultante	
<span><span>    f (  r  , t ) = A  e  i ( k  r  1   −<!-- − --> ω<!-- ω --> t + α<!-- α --> )   {\displaystyle f({\bold {r}},t)=Ae^{i(kr_{1}-\omega t+\alpha )}}  </span></span>	(220)

Ampiezza	
<span><span>    A =    √<!-- √ -->  A  1   2   +  A  2   2   + 2  A  1    A  2    cos ⁡<!-- ⁡ --> δ<!-- δ -->   {\displaystyle A={\sqrt {A_{1}^{2}+A_{2}^{2}+2A_{1}A_{2}\cos \delta }}}  </span></span>	(221)

Diff. cammino ottico	
<span><span>    δ<!-- δ --> =  α<!-- α -->  2   −<!-- − -->  α<!-- α -->  1   = (  Φ<!-- Φ -->  2   −<!-- − -->  Φ<!-- Φ -->  1   + k (  r  2   −<!-- − -->  r  1   )   {\displaystyle \delta =\alpha _{2}-\alpha _{1}=(\Phi _{2}-\Phi _{1}+k(r_{2}-r_{1})}  </span></span>	(222)

Intensità	
<span><span>    I =  I  1   +  I  2   + 2   √<!-- √ -->  I  1    I  2      cos ⁡<!-- ⁡ --> δ<!-- δ -->   {\displaystyle I=I_{1}+I_{2}+2{\sqrt {I_{1}I_{2}}}\cos \delta }  </span></span>	(223)

Fase risultante α	
<span><span>    tan ⁡<!-- ⁡ --> α<!-- α --> =    A  1   sin ⁡<!-- ⁡ -->  α<!-- α -->  1   +  A  2   sin ⁡<!-- ⁡ -->  α<!-- α -->  2     A  1   cos ⁡<!-- ⁡ -->  α<!-- α -->  1   +  A  2   cos ⁡<!-- ⁡ -->  α<!-- α -->  2      {\displaystyle \tan \alpha ={\frac {A_{1}\sin \alpha _{1}+A_{2}\sin \alpha _{2}}{A_{1}\cos \alpha _{1}+A_{2}\cos \alpha _{2}}}}  </span></span>	(224)

Massimi	
<span><span>    δ<!-- δ --> = 2 n π<!-- π -->   {\displaystyle \delta =2n\pi }  </span></span>	(225)

Minimi	
<span><span>    δ<!-- δ --> = ( 2 n + 1 ) π<!-- π -->   {\displaystyle \delta =(2n+1)\pi }  </span></span>	(226)

#### · Condizione di Fraunhofer

<span><span>    θ<!-- θ --> =    Δ<!-- Δ --> y L      {\displaystyle \theta ={\frac {\Delta y}{L}}}  </span></span>	(227)
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L grande tale che tan θ ≈ θ

#### · Interferenza in fase

Diff. cammino ottico	
<span><span>    δ<!-- δ --> = k (  r  2   −<!-- − -->  r  1   ) =    2 π<!-- π -->   λ<!-- λ -->    d sin ⁡<!-- ⁡ --> θ<!-- θ -->   {\displaystyle \delta =k(r_{2}-r_{1})={\frac {2\pi }{\lambda }}d\sin \theta }  </span></span>	(228)

Costruttiva	
<span><span>     r  2   −<!-- − -->  r  1   = n λ<!-- λ --> →<!-- → --> sin ⁡<!-- ⁡ --> θ<!-- θ --> = n   λ<!-- λ --> d        n ∈<!-- ∈ -->  Z    {\displaystyle r_{2}-r_{1}=n\lambda \rightarrow \sin \theta =n{\frac {\lambda }{d}}\quad n\in \mathbb {Z} }  </span></span>	(229)

Distruttiva	
<span><span>     r  2   −<!-- − -->  r  1   =    2 n + 1 2    λ<!-- λ --> →<!-- → --> sin ⁡<!-- ⁡ --> θ<!-- θ --> =    2 n + 1 2    λ<!-- λ --> d        n ∈<!-- ∈ -->  Z    {\displaystyle r_{2}-r_{1}={\frac {2n+1}{2}}\lambda \rightarrow \sin \theta ={\frac {2n+1}{2}}{\frac {\lambda }{d}}\quad n\in \mathbb {Z} }  </span></span>	(230)

#### · Interf. riflessione su lastra sottile

( <i>n</i> indice rifr., <i>t</i> spessore lastra)	
Diff. cammino ottico	
<span><span>    δ<!-- δ --> =    2 π<!-- π -->   λ<!-- λ -->    2 n t   cos ⁡<!-- ⁡ -->  θ<!-- θ -->  t      {\displaystyle \delta ={\frac {2\pi }{\lambda }}{\frac {2nt}{\cos \theta _{t}}}}  </span></span>	(231)

Massimi <i>m</i> ∈ ℕ	
<span><span>    t =    2 m + 1 4 n    λ<!-- λ --> cos ⁡<!-- ⁡ -->  θ<!-- θ -->  t      {\displaystyle t={\frac {2m+1}{4n}}\lambda \cos \theta _{t}}  </span></span>	(232)

Minimi <i>m</i> ∈ ℕ	
<span><span>    t =    m 2 n    λ<!-- λ --> cos ⁡<!-- ⁡ -->  θ<!-- θ -->  t      {\displaystyle t={\frac {m}{2n}}\lambda \cos \theta _{t}}  </span></span>	(233)

#### · Interferenza N fenditure

Diff. cammino ottico	
<span><span>    δ<!-- δ --> =    2 π<!-- π -->   λ<!-- λ -->    d sin ⁡<!-- ⁡ --> θ<!-- θ -->   {\displaystyle \delta ={\frac {2\pi }{\lambda }}d\sin \theta }  </span></span>	(234)

Intensità	
<span><span>    I ( θ<!-- θ --> ) =  I  0    (    sin ⁡<!-- ⁡ --> (   N δ<!-- δ --> 2    )   sin ⁡<!-- ⁡ -->   δ<!-- δ --> 2      )  2      {\displaystyle I(\theta )=I_{0}\left({\frac {\sin(N{\frac {\delta }{2}})}{\sin {\frac {\delta }{2}}}}\right)^{2}}  </span></span>	(235)

Massimi principali <i>m</i> ∈ ℤ	
<span><span>    δ<!-- δ --> = 2 m π<!-- π --> →<!-- → --> sin ⁡<!-- ⁡ --> θ<!-- θ --> =    m λ<!-- λ --> d      {\displaystyle \delta =2m\pi \rightarrow \sin \theta ={\frac {m\lambda }{d}}}  </span></span>	(236)

<span><span>     I  M A X   =  N  2    I  0     {\displaystyle I_{MAX}=N^{2}I_{0}}  </span></span>	(237)
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· <b>Attrito viscoso</b>	
Equazione differenziale	
<span><span>     v ′   +    v τ<!-- τ -->    = K   {\displaystyle v'+{\frac {v}{\tau }}=K}  </span></span>	(267)

Soluzione	
<span><span>    v ( t ) = k τ<!-- τ --> ( 1 −<!-- − -->  e  −<!-- − -->   t τ<!-- τ -->      )   {\displaystyle v(t)=k\tau (1-e^{-{\tfrac {t}{\tau }}})}  </span></span>	(268)

### ■ ANALISI MATEMATICA

#### · Integrali ricorrenti

<span><span>    ∫<!-- ∫ -->    1  x  2   +  r  2      d x =   1 r    arctan ⁡<!-- ⁡ -->   x r      {\displaystyle \int {\frac {1}{x^{2}+r^{2}}}\mathrm {d} x={\frac {1}{r}}\arctan {\frac {x}{r}}}  </span></span>	(269)
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<span><span>    ∫<!-- ∫ -->    1   √<!-- √ -->  x  2   +  r  2      d x = ln ⁡<!-- ⁡ -->   √<!-- √ -->  x  2   +  r  2      + x   {\displaystyle \int {\frac {1}{\sqrt {x^{2}+r^{2}}}}\mathrm {d} x=\ln {\sqrt {x^{2}+r^{2}}}+x}  </span></span>	(270)
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Massimi secondari	
<span><span>    m ∈<!-- ∈ -->  Z  −<!-- − --> { k N , k N −<!-- − --> 1   con   k ∈<!-- ∈ -->  Z  }   {\displaystyle m\in \mathbb {Z} -\{kN,kN-1\}\,\,\mathrm {con} \,\,k\in \mathbb {Z} }  </span></span>	

<span><span>    δ<!-- δ --> =    2 m + 1 2 N    π<!-- π --> →<!-- → --> sin ⁡<!-- ⁡ --> θ<!-- θ --> =    2 m + 1 2 N    λ<!-- λ --> d      {\displaystyle \delta ={\frac {2m+1}{2N}}\pi \rightarrow \sin \theta ={\frac {2m+1}{2N}}{\frac {\lambda }{d}}}  </span></span>	(238)
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<span><span>     I  S E C   =    I  0     ( sin ⁡<!-- ⁡ -->   π<!-- π --> d sin ⁡<!-- ⁡ --> θ<!-- θ --> λ      )  2      {\displaystyle I_{SEC}={\frac {I_{0}}{\left(\sin {\frac {\pi d\sin \theta }{\lambda }}\right)^{2}}}  </span></span>	(239)
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Minimi <i>m</i> ∈ ℤ − { <i>kN</i> }	
-------------------------------------	--

<span><span>    δ<!-- δ --> =    2 m N    π<!-- π --> →<!-- → --> sin ⁡<!-- ⁡ --> θ<!-- θ --> =    m λ<!-- λ --> N d      {\displaystyle \delta ={\frac {2m}{N}}\pi \rightarrow \sin \theta ={\frac {m\lambda }{Nd}}}  </span></span>	(240)
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<span><span>     I  M I N   = 0   {\displaystyle I_{MIN}=0}  </span></span>	(241)
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Separazione angolare (distanza angolare tra min. e max. adiacente)

· Differenziale di primo ordine

Forma generale

$$y'(t) + a(t)y(t) = b(t)$$

(276)

Soluzione

$$y(t) = e^{-A(t)(c+\int b(t)e^{A(t)}dt)}$$

(277)

· Differenziale di secondo ordine omo-geneo

Forma generale

$$y'' + ay' + by = 0 \qquad a, b \in \mathbb{R}$$

(278)

$\lambda_{1,2} \in \mathbb{C}$  sono le soluzioni dell'equazione associata

Soluzioni

Se  $\Delta > 0$

$$y(t) = c_1e^{\lambda_1t} + c_2e^{\lambda_2t}$$

(279)

Se  $\Delta = 0$

$$y(t) = c_1e^{\lambda_1t} + tc_2e^{\lambda_2t}$$

(280)

Se  $\Delta < 0$

$$y(t) = c_1e^{\alpha t} \cos(\beta t) + c_2e^{\alpha t} \sin(\beta t)$$

(281)

con  $\alpha = Re(\lambda)$  e  $\beta = Im(\lambda)$

· Identità vettoriali

$$\nabla \cdot (\nabla \times \mathbf{A}) = 0$$

(282)

$$\nabla \times (\nabla f) = 0$$

(283)

$$\nabla \cdot (f \mathbf{A}) = f \nabla \cdot \mathbf{A} + \mathbf{A} \cdot \nabla f$$

(284)

$$\nabla (\mathbf{A} \cdot \mathbf{B}) = \mathbf{B} \cdot (\nabla \times \mathbf{A}) - \mathbf{A} \cdot (\nabla \times \mathbf{B})$$

(285)

$$\nabla \times (\nabla \times \mathbf{A}) = \nabla (\nabla \cdot \mathbf{A}) - \nabla^2 \mathbf{A}$$

(286)

$$\mathbf{A} \times (\mathbf{B} \times \mathbf{C}) = \mathbf{B}(\mathbf{A} \cdot \mathbf{C}) - \mathbf{C}(\mathbf{A} \cdot \mathbf{B})$$

(287)

· Identità geometriche

$$\sin(\alpha \pm \beta) = \sin \alpha \cos \beta \pm \cos \alpha \sin \beta$$

(288)

$$\cos(\alpha \pm \beta) = \cos \alpha \cos \beta \mp \sin \alpha \sin \beta$$

(289)

$$\cos \frac{\alpha}{2} = \pm \sqrt{\frac{1 + \cos \alpha}{2}}$$

(290)

$$\sin \frac{\alpha}{2} = \pm \sqrt{\frac{1 - \cos \alpha}{2}}$$

(291)

$$\tan \frac{\alpha}{2} = \frac{1 - \cos \alpha}{\sin \alpha} = \frac{\sin \alpha}{1 + \cos \alpha}$$

(292)

	Cartesiane	Sferiche	Cilindriche
Gradiente ( $\nabla f =$ )	$\frac{\partial f}{\partial x} \mathbf{x} + \frac{\partial f}{\partial y} \mathbf{y} + \frac{\partial f}{\partial z} \mathbf{z}$	$\frac{\partial f}{\partial r} \mathbf{r} + \frac{1}{r} \frac{\partial f}{\partial \theta} \boldsymbol{\theta} + \frac{1}{r \sin \theta} \frac{\partial f}{\partial \phi} \boldsymbol{\phi}$	$\frac{\partial f}{\partial r} \mathbf{r} + \frac{1}{r} \frac{\partial f}{\partial \theta} \boldsymbol{\theta} + \frac{\partial f}{\partial z} \mathbf{z}$
Divergenza ( $\nabla \cdot \mathbf{F} =$ )	$\frac{\partial F_x}{\partial x} + \frac{\partial F_y}{\partial y} + \frac{\partial F_z}{\partial z}$	$\frac{1}{r^2} \frac{\partial r^2 F_r}{\partial r} + \frac{1}{r \sin \theta} \frac{\partial F_\theta \sin \theta}{\partial \theta} + \frac{1}{r \sin \theta} \frac{\partial F_\phi}{\partial \phi}$	$\frac{1}{r} \frac{\partial (r F_r)}{\partial r} + \frac{1}{r} \frac{\partial F_\theta}{\partial \theta} + \frac{\partial F_z}{\partial z}$
Rotore ( $\nabla \times \mathbf{F} =$ )	$\begin{pmatrix} \frac{\partial F_z}{\partial y} - \frac{\partial F_y}{\partial z} \\ \frac{\partial F_x}{\partial z} - \frac{\partial F_z}{\partial x} \\ \frac{\partial F_y}{\partial x} - \frac{\partial F_x}{\partial y} \end{pmatrix}$	$\begin{pmatrix} \frac{1}{r \sin \theta} \left( \frac{\partial F_\phi \sin \theta}{\partial \theta} - \frac{\partial F_\theta}{\partial \phi} \right) \\ \frac{1}{r} \left( \frac{1}{\sin \theta} \frac{\partial F_r}{\partial \phi} - \frac{\partial (r F_\phi)}{\partial r} \right) \\ \frac{1}{r} \left( \frac{\partial (r F_\theta)}{\partial r} - \frac{\partial F_r}{\partial \theta} \right) \end{pmatrix}$	$\begin{pmatrix} \left( \frac{1}{r} \frac{\partial F_z}{\partial \phi} - \frac{\partial F_\phi}{\partial z} \right) \\ \left( \frac{\partial F_r}{\partial z} - \frac{\partial F_z}{\partial r} \right) \\ \frac{1}{r} \left( \frac{\partial (r F_\phi)}{\partial r} - \frac{\partial F_r}{\partial \phi} \right) \end{pmatrix}$
Il laplaciano di un campo scalare $\Phi$ , in qualunque coordinata, è $\nabla \cdot \nabla \Phi$			