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 Buona fortuna per l'esame!

NOME:
 COGNOME:
 MATRICOLA:

<div>■ FONDAMENTALI</div> <div>· Teorema (divergenza)</div> $\int_{\Sigma} \mathbf{F} \cdot d\mathbf{\Sigma} = \int_{\tau} \nabla \cdot \mathbf{F} d\tau$ <div>· Teorema (Stokes)</div> $\oint_{\gamma} \mathbf{F} \cdot d\mathbf{s} = \int_{\Sigma} \nabla \times \mathbf{F} d\mathbf{\Sigma}$ <div>· Teorema (Gradiente)</div> $\phi_2 - \phi_1 = \int_{\gamma} \nabla \phi \cdot d\mathbf{s}$ <div>· Flusso di un campo</div> $\Phi_{\Sigma}(\mathbf{E}) = \oint_{\Sigma} \mathbf{E} \cdot d\mathbf{\Sigma}$ <div>· Equazioni di Maxwell 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>· Discontinuità dei campi 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 $\sigma_L = 0$</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>· Potenziale scalare V</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>· Energia di E</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>· Equazione di Poisson</div> $\nabla^2 V = -\frac{\rho}{\varepsilon_0}$ <div>· E e V di particolari distribuzioni 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 λ</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 Σ 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> $\mathbf{E}(x) = \frac{\sigma}{2\varepsilon_0} \left(1 - \frac{1}{\sqrt{1 + \frac{R^2}{x^2}}}\right) \mathbf{u}_x$ $V(x) = \frac{\sigma}{2\varepsilon_0} (x - \sqrt{x^2 + R^2})$ <div>Disco carico uniformemente ($x \gg R$)</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>■ ELETTROSTATICA</div> <div>· Forza di Coulomb</div> $\mathbf{F} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2} \mathbf{u}_{1,2}$ <div>· Definizione campo elettrico</div> $\mathbf{E} = \frac{\mathbf{F}(\mathbf{r}_0)}{q_0}$ <div>· En. potenziale due cariche</div> $U = \frac{q_1 q_2}{4\pi\varepsilon_0 r_{1,2}} + c$	<div>(27)</div>
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<div>· Conduttori in equilibrio 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>· Pressione elettrostatica</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>· Capacità</div> $C = \frac{Q}{\Delta V}$ <div>Il più delle volte c'è induzione completa e C dipende dalla configurazione geometrica.</div> <div>· Condensatori 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> $U = \frac{Q^2}{2C} = \frac{1}{2} CV = \frac{1}{2} QV$ <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>· Condensatore pieno Condensatore riempito di materiale di resistività ρ</div> $RC = \varepsilon_0 \rho$ <div>· Forza fra le armature</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>· Campo elettrico E generato</div> $\mathbf{E} = \frac{qd \left(2 \cos(\theta) \mathbf{u}_r + \sin(\theta) \mathbf{u}_{\theta} \right)}{4\pi\varepsilon r^3}$ <div>· Momento torcente</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>· Lavoro per ruotarlo</div> $W = \int_{\theta_i}^{\theta_f} M d\theta$ <div>Se E uniforme</div> $W = pE [\cos(\theta_i) - \cos(\theta_f)]$ <div>· Frequenza dipolo oscillante Se E costante e uniforme</div> $\nu = \frac{1}{2\pi} \sqrt{\frac{pE}{I}}$ <div>· Energia del dipolo</div> $U = -\mathbf{p} \cdot \mathbf{E}$ <div>· Forza agente sul dipolo</div> $\mathbf{F} = \nabla(\mathbf{p} \cdot \mathbf{E})$ <div>· Energia pot. tra due dipoli</div> $U = \frac{[\mathbf{p}_1 \cdot \mathbf{p}_2 - 3(\mathbf{p}_1 \mathbf{u}_r)(\mathbf{p}_2 \cdot \mathbf{u}_r)]}{4\pi\varepsilon_0 r^2}$ <div>· Forza tra dipoli 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>■ DIELETTRICI</div> <div>· Campo elettrico in un dielettrico</div> $\mathbf{E}_k = \frac{\mathbf{E}_0}{k}$ <div>· Vettore P polarizzazione</div> $\mathbf{P} = \frac{dp}{d\tau}$ <div>· Dielettrici lineari</div> $\mathbf{P} = \varepsilon_0 \chi_E \mathbf{E}_k = \varepsilon_0 (k - 1) \mathbf{E}_k$ <div>· Dens. superficiale di q polarizzata</div> $\sigma_p = \mathbf{P} \cdot \mathbf{u}_n = \frac{k-1}{k} \sigma_l$ <div>· Dens. volumetrica di q polarizzata</div> $\rho_p = -\nabla \cdot \mathbf{P}$ <div>· Spostamento elettrico</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>■ CORRENTI</div> <div>· Lavoro del generatore</div> $W_{gen} = \int_{t_1}^{t_2} V dq(t) = 2U_E$ <div>· Densità di corrente</div> $\mathbf{J} = nq\mathbf{v} = \frac{Nq\mathbf{v}}{\tau}$ <div>· Intensità di corrente</div> $I = \frac{dq(t)}{dt} = \int_{\Sigma} \mathbf{J} \cdot d\mathbf{\Sigma}$ <div>· Leggi di Ohm</div> $V = RI$ $dR = \int_{\Gamma} \frac{\rho}{\Sigma} dl$ $\mathbf{E} = \rho \mathbf{J}$ $\rho = \frac{1}{\sigma}$	<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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· Effetto Joule	
 ⟨<!-- ⟨ --> P R ⟩<!-- ⟩ --> = V 0 2 R {\displaystyle \langle P_{R}\rangle ={\frac {V_{0}}{2R}}} 	(180)
· Potenza media totale	
 ⟨<!-- ⟨ --> P ⟩<!-- ⟩ --> = V 0 I 0 2 cos ⁡<!-- ⁡ --> (ϕ<!-- ϕ -->) {\displaystyle \langle P\rangle ={\frac {V_{0}I_{0}}{2}}\cos(\phi)} 	(181)
· V e I efficace	
 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}} 	(182)

■ CAMPO EM e OTTICA

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

■ UNITÀ DI MISURA

 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}}}} 	(255)
 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}}}} 	(256)
 T = N A m = k g A s 2 {\displaystyle T={\frac {N}{Am}}={\frac {kg}{As^{2}}}} 	(257)
 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}}} 	(258)
 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}}} 	(259)

■ FISICA 1

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

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

· Legge di Snell-Cartesio

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

Definizione	
 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}}}} 	(200)

 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}}}} 	(201)
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Raggio RIFLESSO polarizzato	
 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})}}} 	(202)

 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})}}} 	(203)
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 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}} 	(204)
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Raggio TRASMESSO polarizzato	
 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}}}} 	(205)

 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}}}} 	(206)
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 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 }} 	(207)
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Luce NON polarizzata	
 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 })} 	(208)

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

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

 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}}}} 	(213)
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 R = 1 2 cos 2 ⁡<!-- ⁡ --> (2 θ<!-- θ --> i) {\displaystyle R={\frac {1}{2}}\cos ^{2}(2\theta _{i})} 	(214)
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 T = 1 −<!-- − --> R {\displaystyle T=1-R} 	(215)
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· Pressione di radiazione

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

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

· Rapporto di polarizzazione

 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 }}}}} 	(218)
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 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 }}}}} 	(219)
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■ INTERFERENZA e DIFFRAZIO-NE

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

· Moto circolare unif. accelerato

 v = ω<!-- ω --> r {\displaystyle v=\omega r} 	(262)
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 a = v 2 r = ω<!-- ω --> 2 r {\displaystyle a={\frac {v^{2}}{r}}=\omega ^{2}r} 	(263)
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 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}} 	(264)
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· Moto armonico

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

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

· Interferenza generica

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

Ampiezza	
 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 }}} 	(221)

Diff. cammino ottico	
 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})} 	(222)

Intensità	
 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 } 	(223)

Fase risultante α	
 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}}}} 	(224)

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

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

· Condizione di Fraunhofer

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

Diff. cammino ottico	
 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 } 	(228)

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

Distruttiva	
 r 2 −<!-- − --> r 1 = 2 n + 1 2 λ<!-- λ --> →<!-- → --> sin ⁡<!-- ⁡ --> θ<!-- θ --> = 2 n + 1 2 λ<!-- λ --> d n ∈<!-- ∈ --> Z<!-- 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} } 	(230)

· Interf. riflessione su lastra sottile

(<i>n</i> indice rifr., <i>t</i> spessore lastra)	
Diff. cammino ottico	
 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}}}} 	(231)

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

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

· Interferenza N fenditure

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

Intensità	
 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}} 	(235)

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

 I M A X = N 2 I 0 {\displaystyle I_{MAX}=N^{2}I_{0}} 	(237)
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· Attrito viscoso

Equazione differenziale	
 v ′ + v τ = K {\displaystyle v'+{\frac {v}{\tau }}=K} 	(267)

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

■ ANALISI MATEMATICA

· Integrali ricorrenti

 ∫<!-- ∫ --> 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}}} 	(269)
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 ∫<!-- ∫ --> 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} 	(270)
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Massimi secondari	
 m ∈<!-- ∈ --> Z<!-- Z --> −<!-- − --> { k N , k N −<!-- − --> 1 con k ∈<!-- ∈ --> Z<!-- Z --> } {\displaystyle m\in \mathbb {Z} -\{kN,kN-1\ {\rm {con}}\ k\in \mathbb {Z} } } 	

 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}}} 	(238)
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 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}}} 	(239)
--	-------

Minimi <i>m</i> ∈ ℤ − { <i>kN</i> }	
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 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}}} 	(240)
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 I M I N = 0 {\displaystyle I_{MIN}=0} 	(241)
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· 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 ($\nabla f =$)	$\frac{\partial f}{\partial x} \mathbf{x} + \frac{\partial f}{\partial y} \mathbf{y} + \frac{\partial f}{\partial z} \mathbf{z}$	$\frac{\partial f}{\partial r} \mathbf{r} + \frac{1}{r} \frac{\partial f}{\partial \theta} \theta + \frac{1}{r \sin \theta} \frac{\partial f}{\partial \phi} \phi$	$\frac{\partial f}{\partial r} \mathbf{r} + \frac{1}{r} \frac{\partial f}{\partial \theta} \theta + \frac{\partial f}{\partial z} \mathbf{z}$
Divergenza ($\nabla \cdot \mathbf{F} =$)	$\frac{\partial F_x}{\partial x} + \frac{\partial F_y}{\partial y} + \frac{\partial F_z}{\partial z}$	$\frac{1}{r^2} \frac{\partial r^2 F_r}{\partial r} + \frac{1}{r \sin \theta} \frac{\partial F_\theta \sin \theta}{\partial \theta} + \frac{1}{r \sin \theta} \frac{\partial F_\phi}{\partial \phi}$	$\frac{1}{r} \frac{\partial F_r}{\partial r} + \frac{1}{r} \frac{\partial F_\theta}{\partial \theta} + \frac{\partial F_z}{\partial z}$
Rotore ($\nabla \times \mathbf{F} =$)	$\begin{pmatrix} \frac{\partial F_z}{\partial y} - \frac{\partial F_y}{\partial z} \\ \frac{\partial F_x}{\partial z} - \frac{\partial F_z}{\partial x} \\ \frac{\partial F_y}{\partial x} - \frac{\partial F_x}{\partial y} \end{pmatrix}$	$\begin{pmatrix} \frac{1}{r \sin \theta} \left(\frac{\partial F_\phi \sin \theta}{\partial \theta} - \frac{\partial F_\theta}{\partial \phi} \right) \\ \frac{1}{r} \left(\frac{1}{\sin \theta} \frac{\partial F_r}{\partial \phi} - \frac{\partial (r F_\phi)}{\partial r} \right) \\ \frac{1}{r} \left(\frac{\partial (r F_\theta)}{\partial r} - \frac{\partial F_r}{\partial \theta} \right) \end{pmatrix}$	$\begin{pmatrix} \left(\frac{1}{r} \frac{\partial F_z}{\partial \phi} - \frac{\partial F_\phi}{\partial z} \right) \\ \left(\frac{\partial F_r}{\partial z} - \frac{\partial (r F_z)}{\partial r} \right) \\ \frac{1}{r} \left(\frac{\partial (r F_\phi)}{\partial r} - \frac{\partial F_r}{\partial \phi} \right) \end{pmatrix}$
Il laplaciano di un campo scalare Φ , in qualunque coordinata, è $\nabla \cdot \nabla \Phi$			