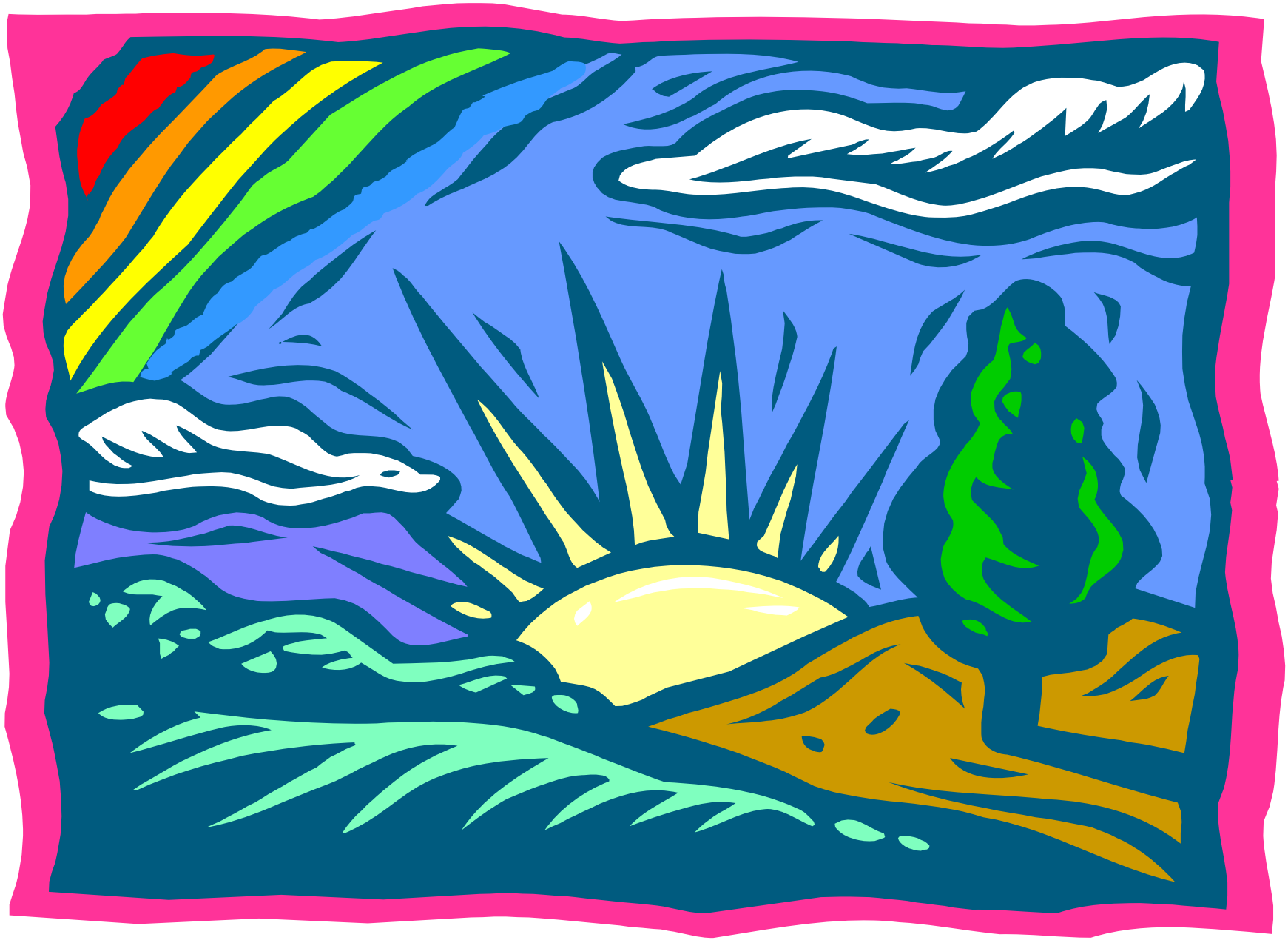

ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO
gradiente
A.G. Antunha

objetivo:

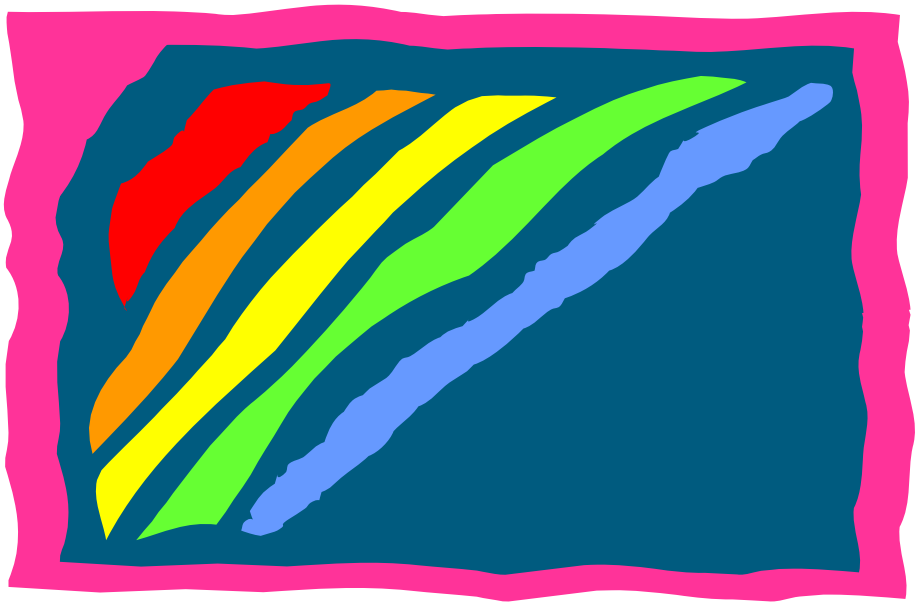
representar a variação de um campo escalar no espaço

$$\left(\frac{d\varphi}{d\vec{r}}\right)_t$$

instantâneo

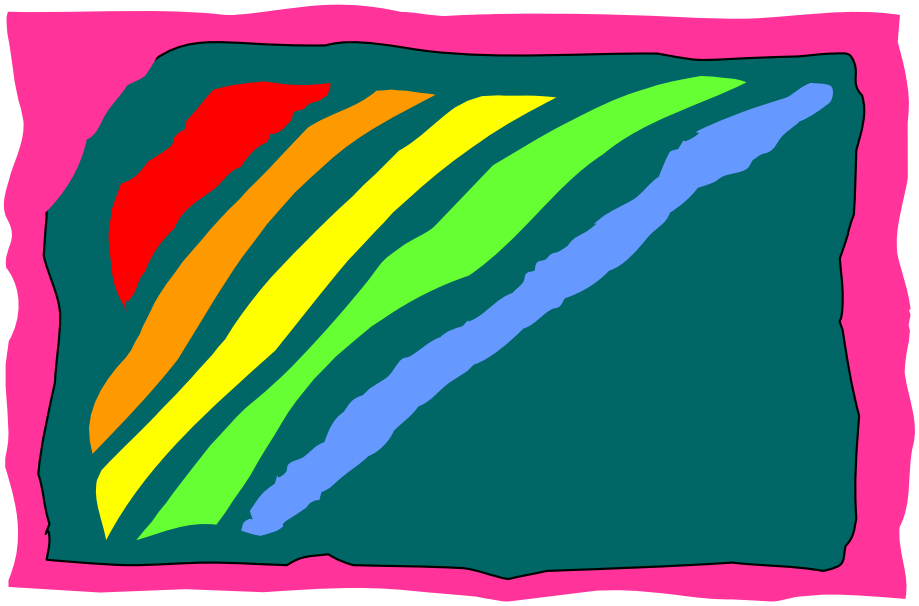


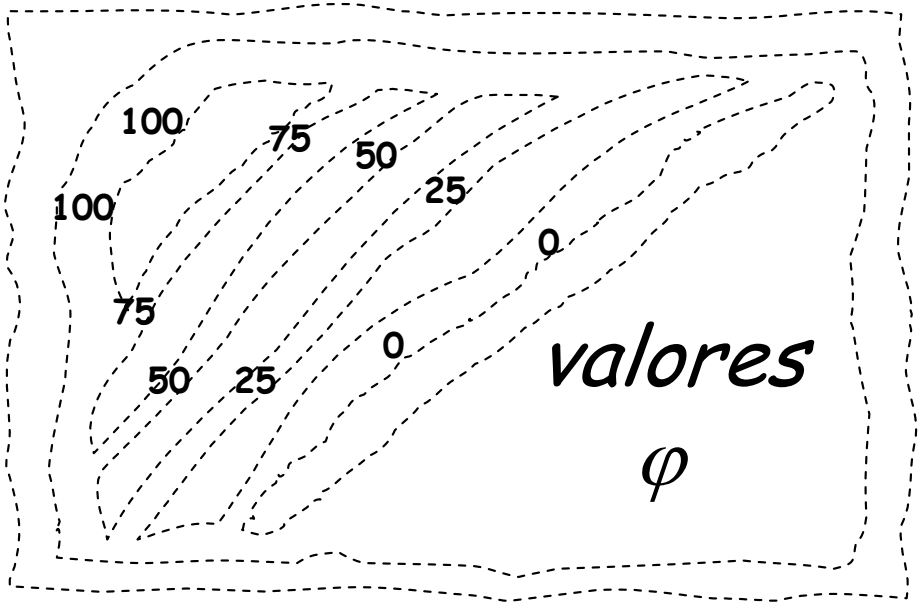

espaço
φ = cor
espaço

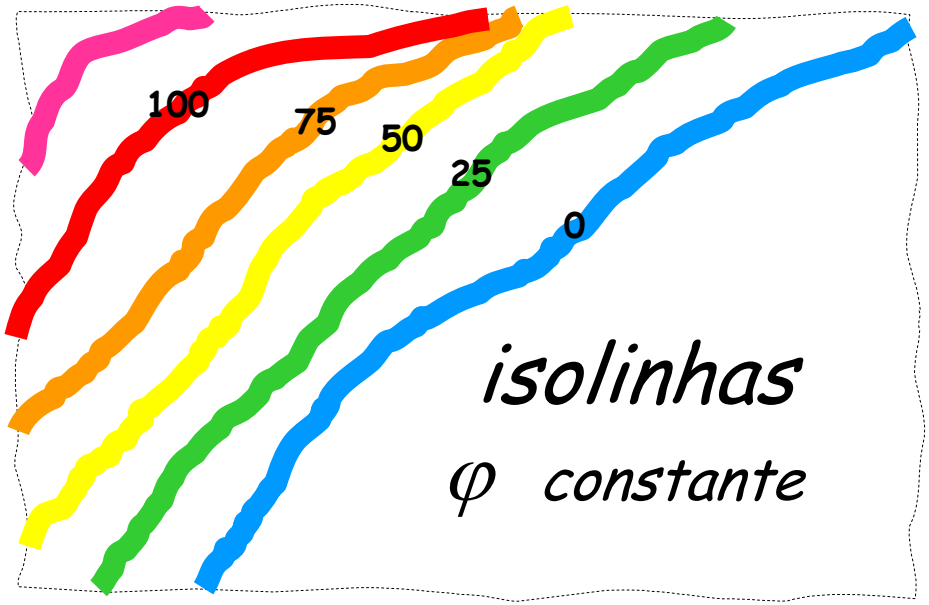


caracterizando um campo escalar φ variável

modos



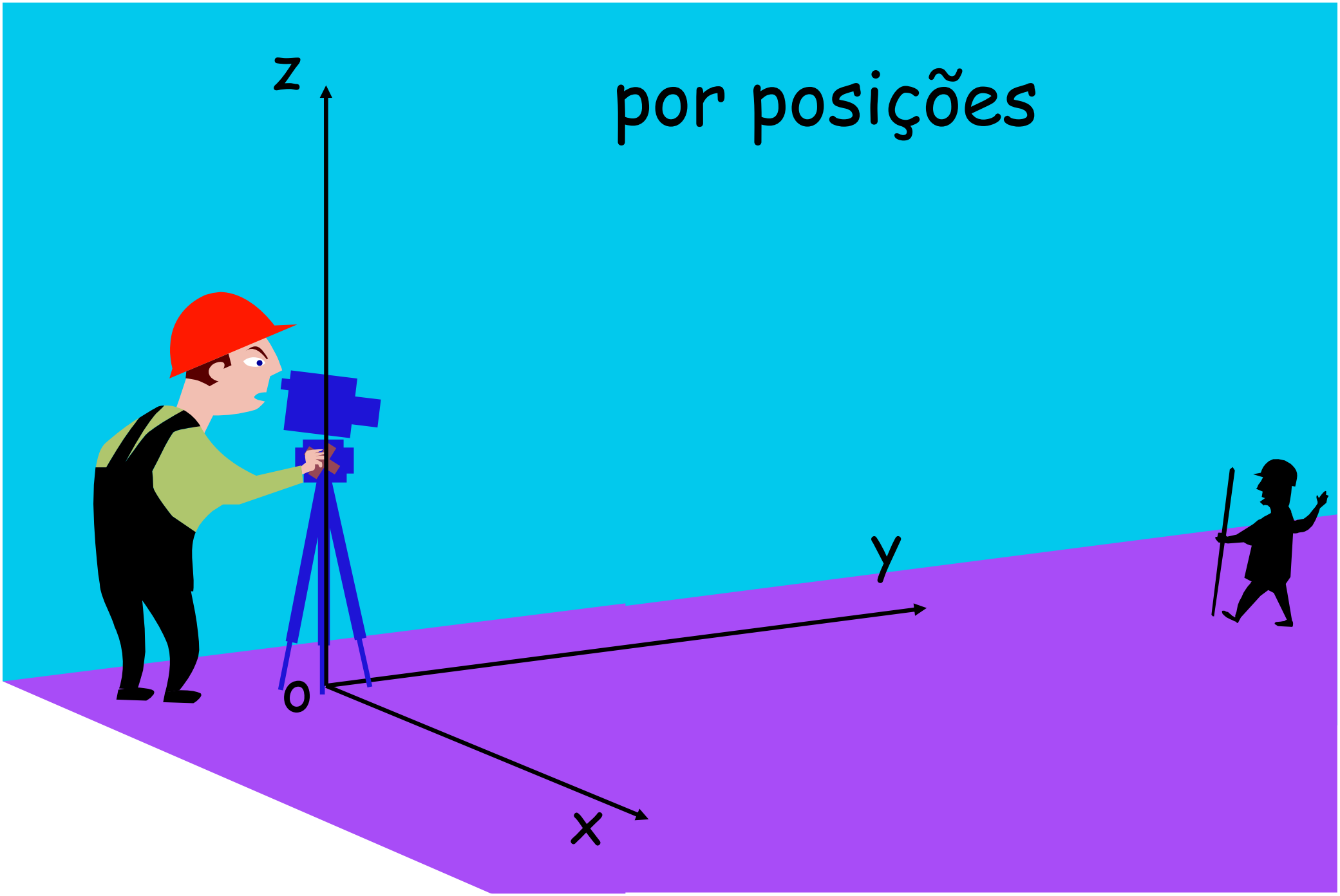

100
75
50
25
0
100
75
50
25
0
valores
φ


100
75
50
25
0
isolinhas
φ constante

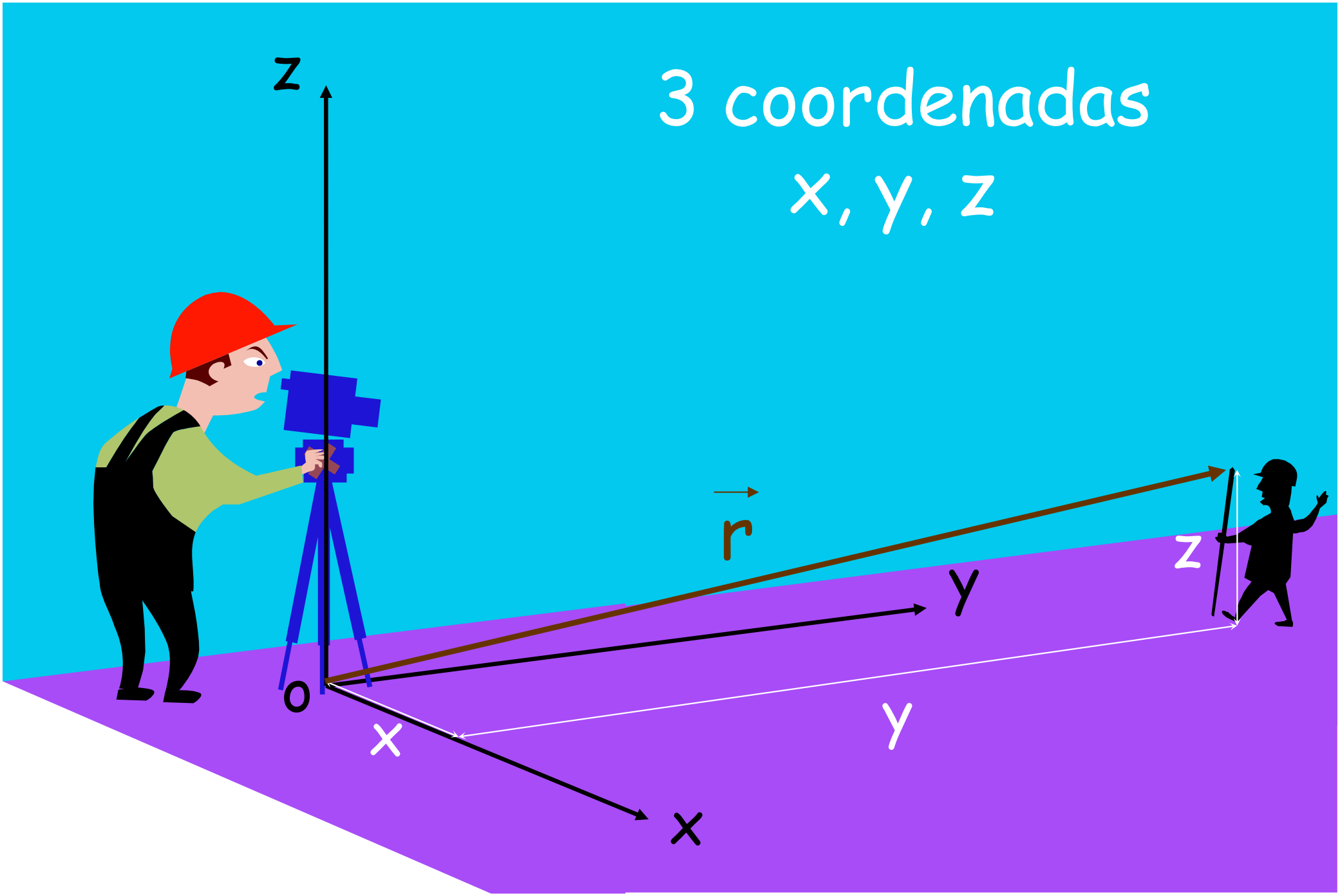

gradação
contínua

caracterizando o espaço

posições



coordenadas



$$\vec{r} = x\vec{I} + y\vec{J} + z\vec{K} =$$

$$= r\vec{e}_r =$$

$$= r'\vec{e}_{r'} + z\vec{K}$$

definição independente do sistema:

derivada do campo escalar φ em relação ao espaço, com t fixo

$$\left(\frac{d\varphi}{d\vec{r}}\right)_t = \frac{\partial\varphi}{\partial\vec{r}} = \vec{grad}\,\varphi$$

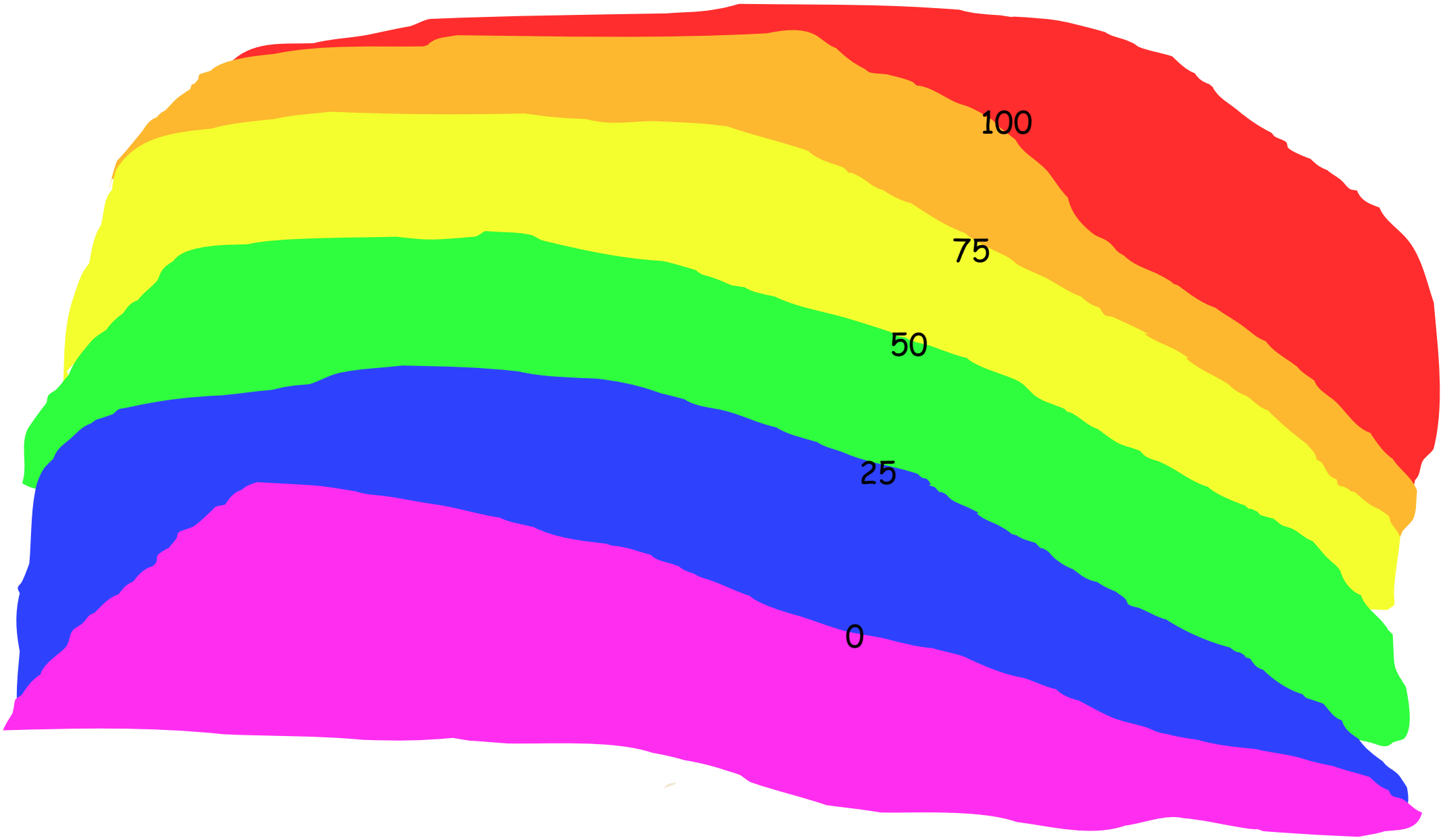
escalar

$$\left(\frac{d\varphi}{d\vec{r}}\right)_t = \vec{grad}\,\varphi$$

$$(d\varphi)_t = \vec{grad}\,\varphi . (d\vec{r})_t$$

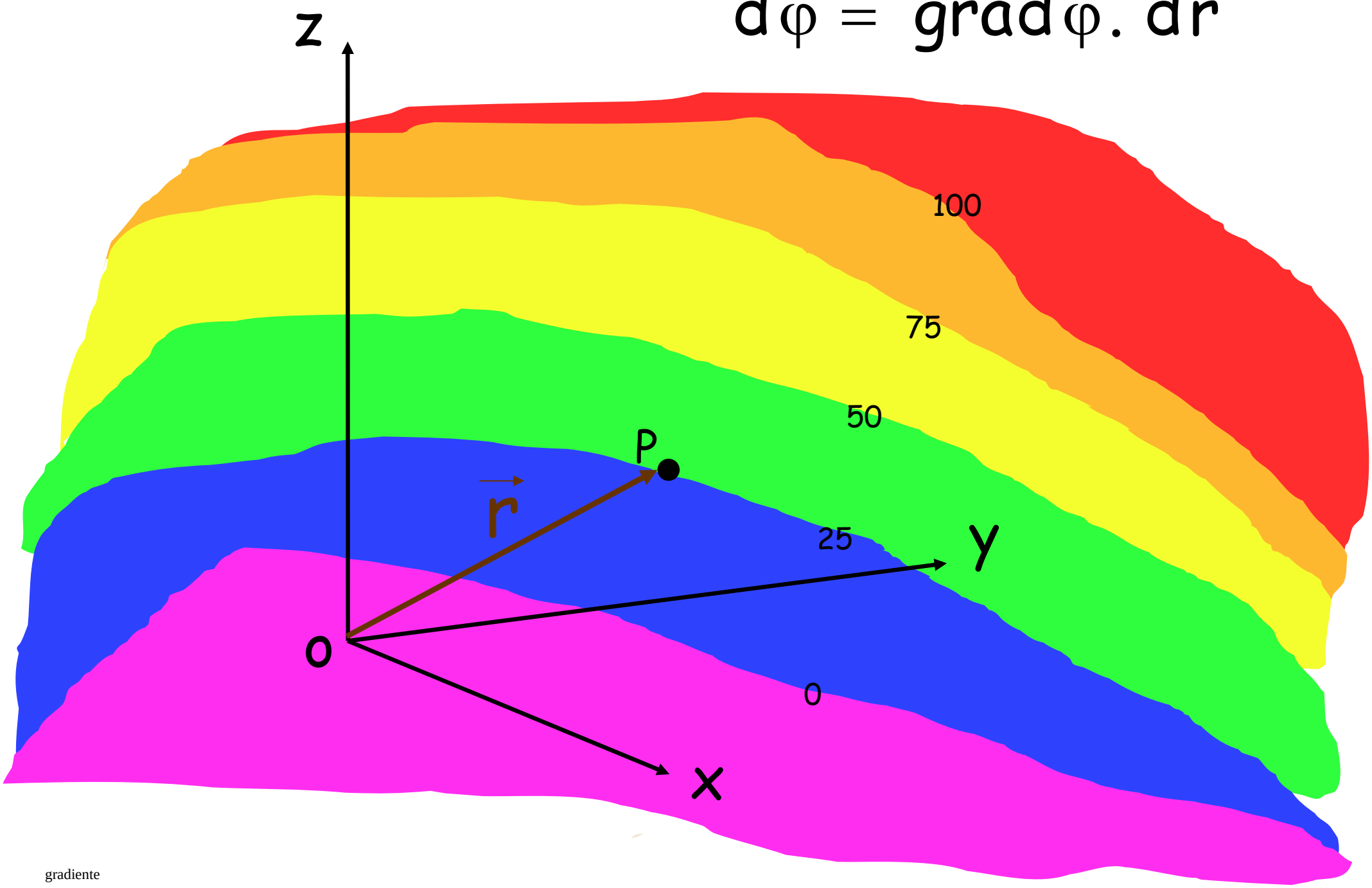
[t = constante]

isolinhas

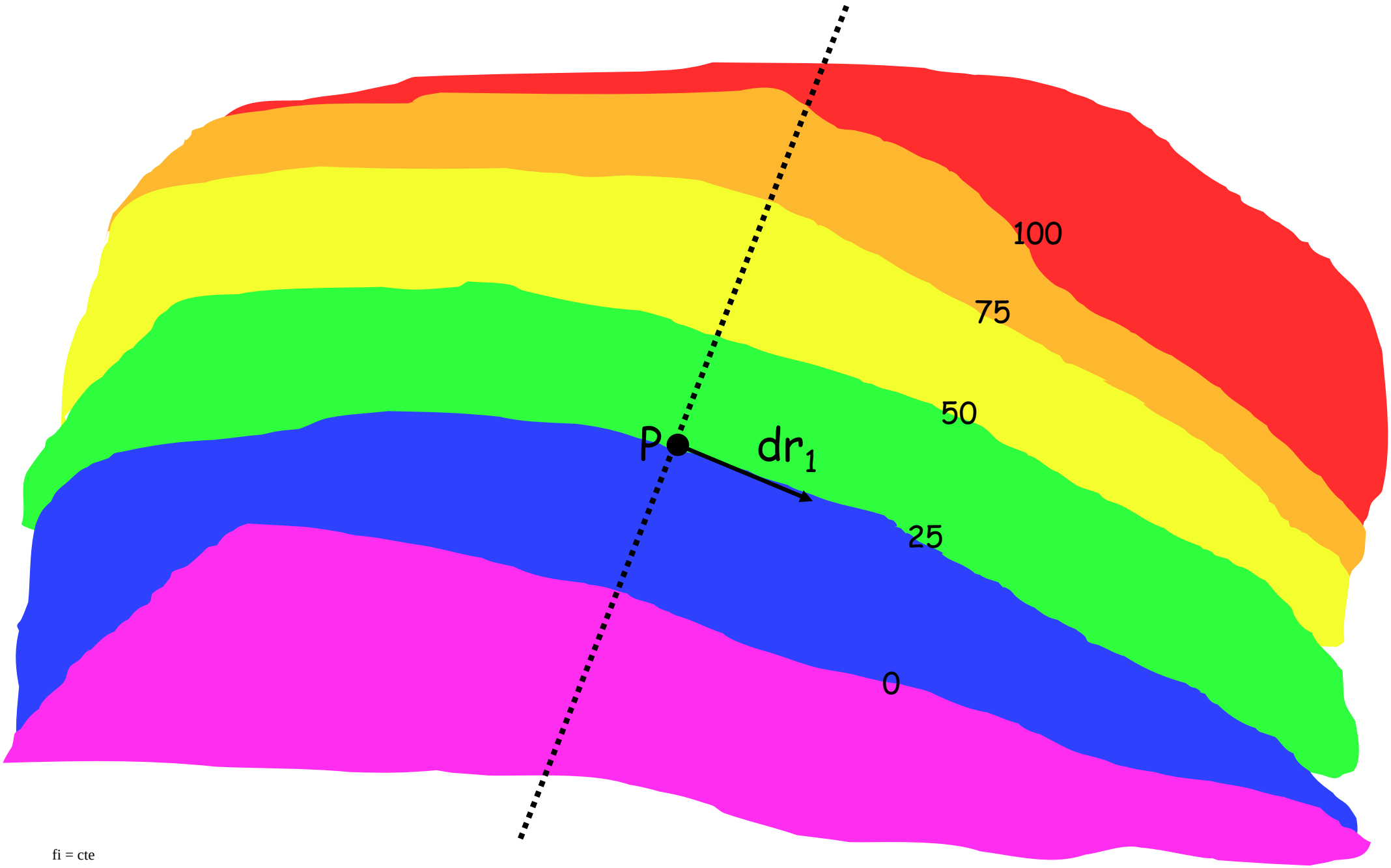


t = constante

$$d\varphi = \vec{grad}\varphi . d\vec{r}$$



$$d\varphi = 25 - 25 = 0 = d\vec{r}_1 \cdot \vec{grad}\,\varphi$$



fi = cte

$$d\varphi = \vec{grad}\,\varphi \,.\, d\vec{r} =$$

$$= [(grad\,\varphi)_x, (grad\,\varphi)_y, (grad\,\varphi)_z] \,.\, [dx, dy, dz] =$$

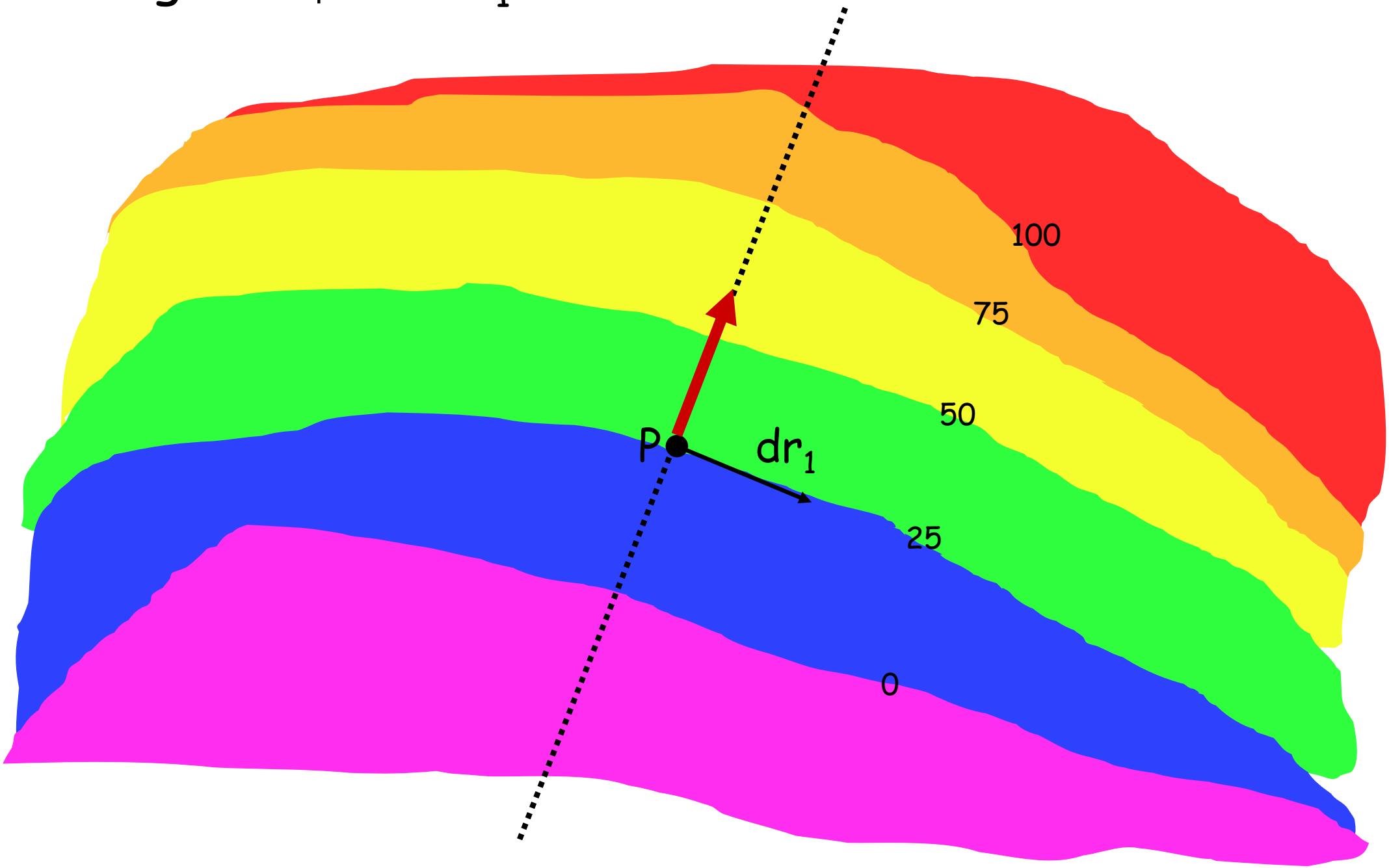
$$= (grad\,\varphi)_x\, dx + (grad\,\varphi)_y\, dy + (grad\,\varphi)_z\, dz = 0$$

$$\Downarrow$$

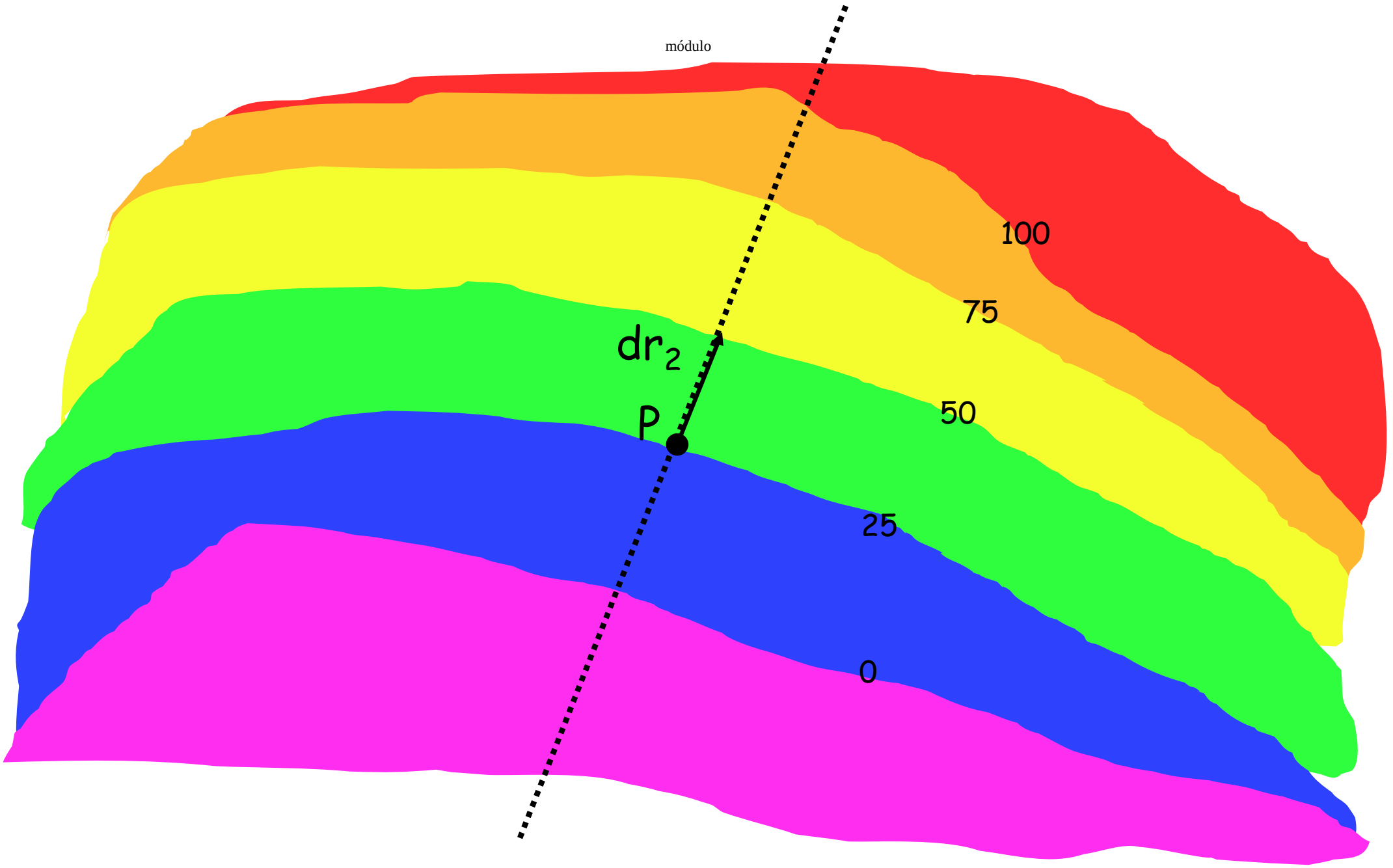
$$\vec{grad}\,\varphi \perp d\vec{r}$$

perpendicular

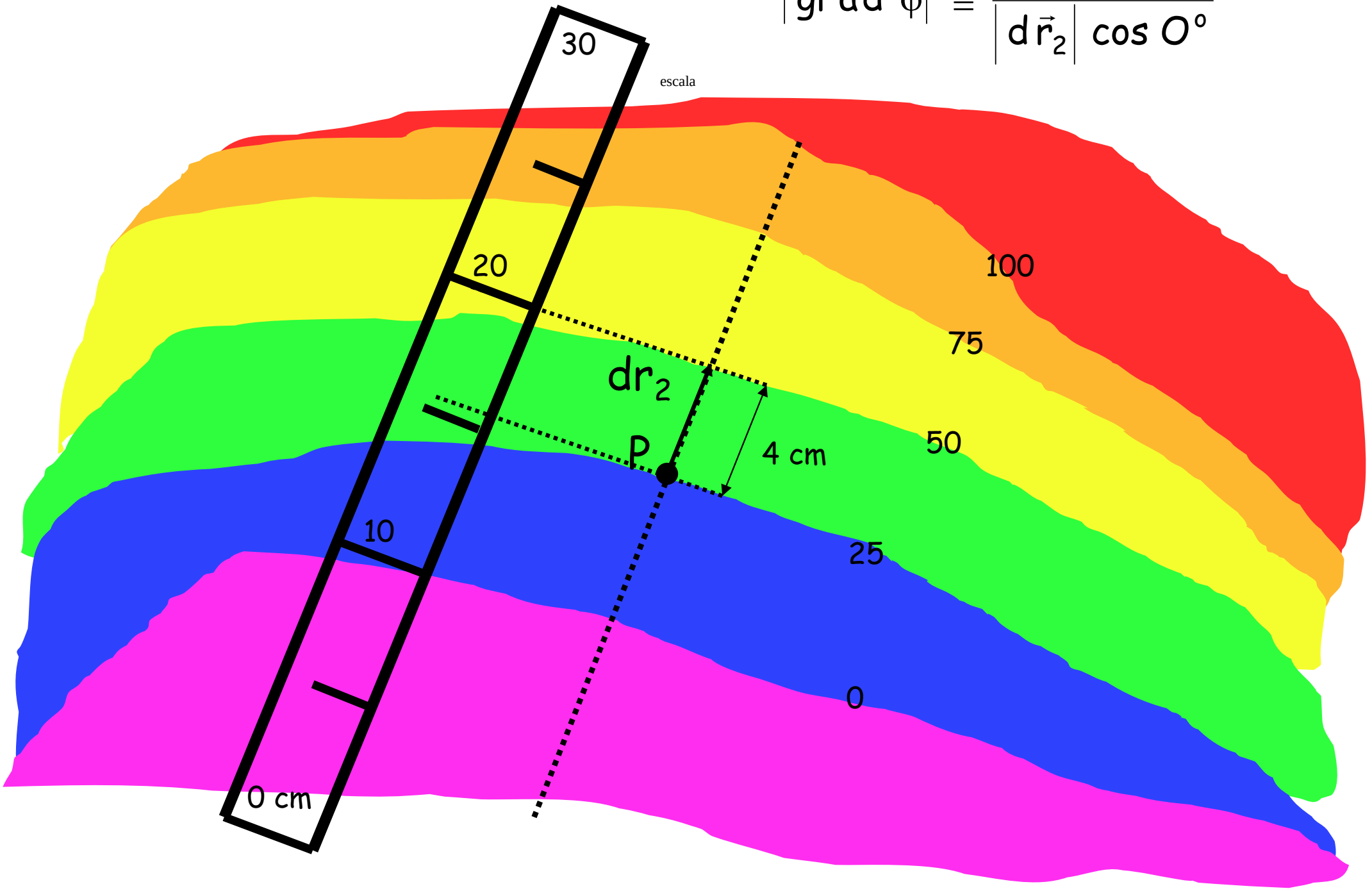
$$\vec{grad}\ \varphi \perp d\vec{r}_1$$



$$d\varphi = d\vec{r}_2 \,.\, \vec{grad}\,\varphi \cong 50 - 25 \rightarrow \left|d\vec{r}_2\right| \left|\vec{grad}\,\varphi\right| \cos 0^\circ \cong 25$$

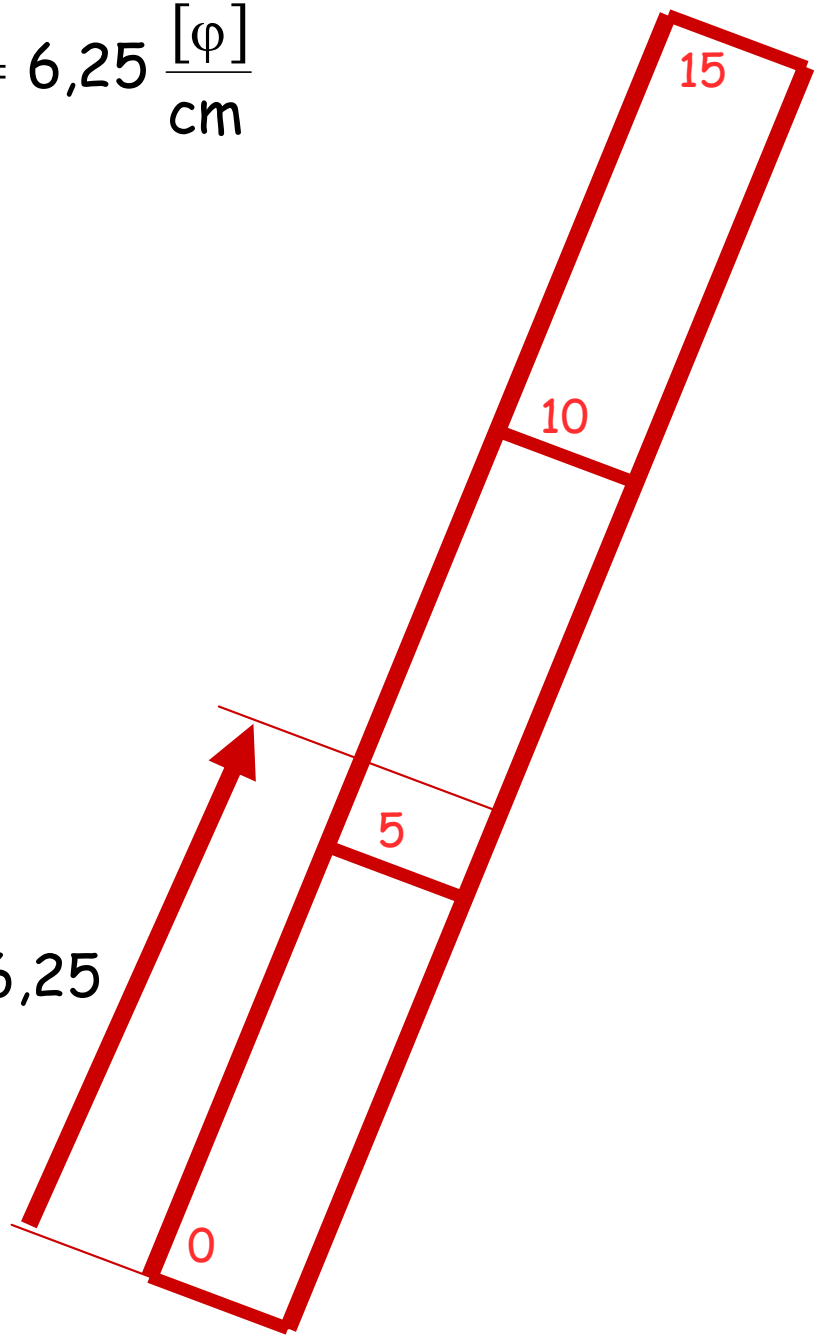


$$\left|\vec{\text{grad}}\ \varphi\right| \cong \frac{25}{\left|d\vec{r}_2\right| \cos 0^\circ}$$



$$\left|\text{grad}\ \varphi\right| \cong \frac{25}{\left|d\vec{r}_2\right| \cos 0^\circ} \cong \frac{25}{(20-16)\,1} = 6{,}25\ \frac{[\varphi]}{\text{cm}}$$

comparação



escala em $[\varphi]$/cm

6,25


f(ponto)
100
75
50
25
0
P
Q
R

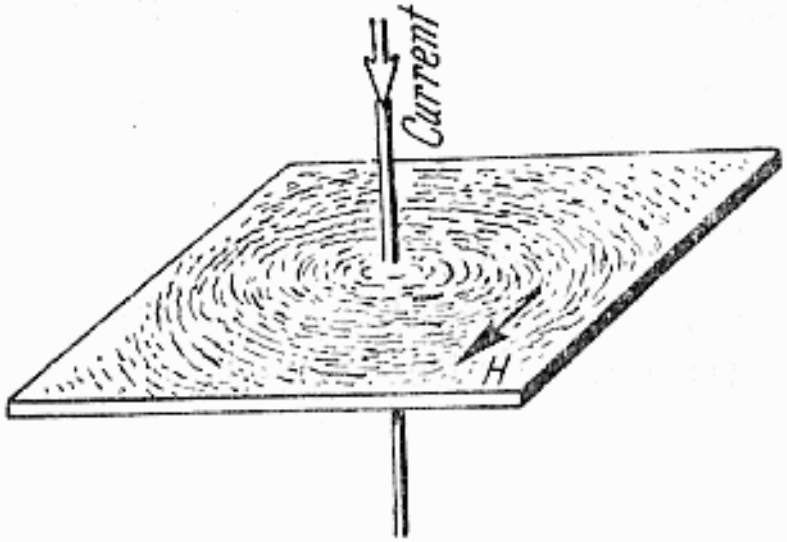


Fig. 51. Magnetic lines of force of a straight wire carrying current, pattern formed by iron filings.

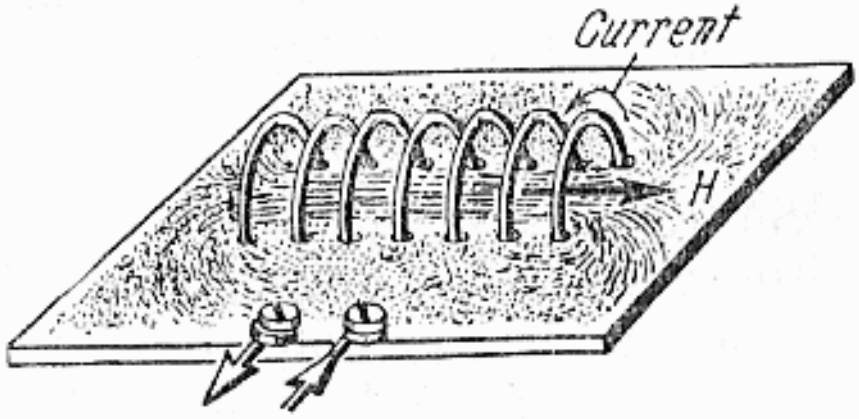


Fig. 52. Magnetic field due to current in a solenoid, pattern formed by iron filings.