a). Find the earth	resistance of a driven rod of length 3m and diameter 2cm, if soil
resistivity is 60) ohm-m.
b). Find the radius above driven r	s of a hemispherical electrode which has the same resistance as the od.
Solution:	
d).	
Rod _{len1} ≔3 m	$\operatorname{Rod}_{\operatorname{dia}} := 0.02 \text{ m} \qquad \rho_{\operatorname{soil1}} := 60 \text{ ohm} \cdot \text{m}$
ρ_{soil1}	$(4 \cdot \text{Rod}_{\text{len1}})$
$R = 2 \cdot \pi \cdot \text{Rod}_{\text{len1}}$	· III (Rod _{dia})
R = 20.362 Ω	This is not the ohmic resistance of the electrode but represent
	the of the mass of earth surrounding the earth electrode (ie ground rod)
b)	
D).	
R = p / (2 pi B)	
$R = p / (2 \text{ pi } B)$ $B_1 \coloneqq \frac{\rho_{\text{soil1}}}{(2 \cdot \pi \cdot R)}$	
$R = p / (2 pi B)$ $B_1 := \frac{\rho_{soil1}}{(2 \cdot \pi \cdot R)}$	
R = p / (2 pi B) B ₁ := $\frac{\rho_{soil1}}{(2 \cdot \pi \cdot R)}$ B ₁ = 0.469 m	Radius of the hemisphere
$R = p / (2 pi B)$ $B_1 := \frac{\rho_{soil1}}{(2 \cdot \pi \cdot R)}$ $B_1 = 0.469 m$	Radius of the hemisphere
$R = p / (2 pi B)$ $B_1 \coloneqq \frac{\rho_{soil1}}{(2 \cdot \pi \cdot R)}$ $B_1 = 0.469 m$	Radius of the hemisphere
$R = p / (2 pi B)$ $B_1 := \frac{\rho_{soil1}}{(2 \cdot \pi \cdot R)}$ $B_1 = 0.469 m$	Radius of the hemisphere
$R = p / (2 pi B)$ $B_1 := \frac{\rho_{soil1}}{(2 \cdot \pi \cdot R)}$ $B_1 = 0.469 m$	Radius of the hemisphere
R = p / (2 pi B) B ₁ := $\frac{\rho_{soi 1}}{(2 \cdot \pi \cdot R)}$ B ₁ = 0.469 m	Radius of the hemisphere Image: Comparison of the hemisphere </td
R = p / (2 pi B) B ₁ := $\frac{\rho_{soil1}}{(2 \cdot \pi \cdot R)}$ B ₁ = 0.469 m	Radius of the hemisphere

a). Find the resistance of two driven rods each of length 3m, and diameter 2cm, and buried in a soil of resistivity 60 ohm-m (clay soil). Spacing between the rods is 3m. b). Find resistance of 3 such rods arranged in a straight line, with 3m spacing between adjacent rods. c). Find the resistance of three such rods arranged in an equilateral triangle with 3m side. d). Find the resistance of four rods arranged at the corners of a square of side 3m Solution: Using the results of Problem 1. See the value of resistance decreasing with more parallel rods, and proximity of rods or configuration (triangle, square, etc) a). $\alpha_{i=} \frac{B_{1}}{Rod_{len1}} \alpha = 0.156$ $R_{2} = R \cdot \left(\frac{1+\alpha}{2}\right)$ $R_{3} := \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^{2})}{6 - 7 \cdot \alpha}$ $R_{3} = 8.544 \Omega$ 3 rods in parallel c). $R_{3,tri} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3,tri} := R \cdot \left(\frac{1+2 \cdot 0 \cdot \alpha}{4}\right)$ $R_{4,sgr} := R \cdot \left(\frac{1+2 \cdot 0 \cdot \alpha}{4}\right)$	Problem 2:	
b). Find resistance of 3 such rods arranged in a straight line, with 3m spacing between adjacent rods. c). Find the resistance of three such rods arranged in an equilateral triangle with 3m side. d). Find the resistance of four rods arranged at the corners of a square of side 3m Solution: Using the results of Problem 1. See the value of resistance decreasing with more parallel rods, and proximity of rods or configuration (triangle, square, etc) a). $\alpha := \frac{B_1}{Rod_{len1}} \qquad \alpha = 0.156$ $R_2 := R \cdot \left(\frac{1 + \alpha}{2}\right)$ $R_2 = 11.773 \ \Omega \qquad 2 \text{ rods in parallel}$ b). $R_3 := \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^2)}{6 - 7 \cdot \alpha}$ $R_3 = 8.544 \ \Omega \qquad 3 \text{ rods in parallel}$ c). $R_{3_{-}tri} := R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{3_{-}tri} := R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{-} = 7.245 \ \Omega \qquad 4 \text{ rods in a square}$	a). Find the resistance buried in a soil of r	of two driven rods each of length 3m, and diameter 2cm, and esistivity 60 ohm-m (clay soil). Spacing between the rods is 3m.
c). Find the resistance of three such rods arranged in an equilateral triangle with 3m side. d). Find the resistance of four rods arranged at the corners of a square of side 3m Solution: Using the results of Problem 1. See the value of resistance decreasing with more parallel rods, and proximity of rods or configuration (triangle, square, etc) a). $\alpha := \frac{B_1}{\text{Rod}_{\text{len1}}} \qquad \alpha = 0.156$ $R_2 := \text{R} \cdot \left(\frac{1+\alpha}{2}\right)$ $R_2 = 11.773 \ \Omega \qquad 2 \text{ rods in parallel}$ b). $R_3 := \frac{\text{R} \cdot (2 + \alpha - 4 \cdot \alpha^2)}{6 - 7 \cdot \alpha}$ $R_3 = 8.544 \ \Omega \qquad 3 \text{ rods in parallel}$ c). $R_{3.\text{tri}} := \text{R} \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3.\text{tri}} := \text{R} \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3.\text{tri}} := \text{R} \cdot \left(\frac{1+2 \cdot 2 \cdot \alpha}{4}\right)$ $R_{4.\text{sqr}} := \text{R} \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4.\text{sqr}} := \text{R} \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$	b). Find resistance of 3 adjacent rods.	3 such rods arranged in a straight line, with 3m spacing between
d). Find the resistance of four rods arranged at the corners of a square of side 3m Solution: Using the results of Problem 1. See the value of resistance decreasing with more parallel rods, and proximity of rods or configuration (triangle, square, etc) a). $\alpha := \frac{B_1}{Rod_{len1}}$ $\alpha = 0.156$ $R_2 := R \cdot \left(\frac{1+\alpha}{2}\right)$ $R_2 = 11.773 \Omega$ 2 rods in parallel b). $R_3 := \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^2)}{6 - 7 \cdot \alpha}$ $R_3 = 8.544 \Omega$ 3 rods in parallel c). $R_3_{tri} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_3_{tri} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_3_{tri} := R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_4_{sqr} := R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$	c). Find the resistance side.	of three such rods arranged in an equilateral triangle with 3m
Solution: Using the results of Problem 1. See the value of resistance decreasing with more parallel rods, and proximity of rods or configuration (triangle, square, etc) a). $\alpha := \frac{B_1}{Rod_{len1}}$ $\alpha = 0.156$ $R_2 := R \cdot \left(\frac{1+\alpha}{2}\right)$ $R_2 = 11.773 \ \Omega$ 2 rods in parallel b). $R_3 := \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^2)}{6 - 7 \cdot \alpha}$ $R_3 = 8.544 \ \Omega$ 3 rods in parallel c). $R_{3_1 tri} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_1 tri} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_1 tri} := R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_1 sqr} := R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$	d). Find the resistance	of four rods arranged at the corners of a square of side 3m
Using the results of Problem 1. See the value of resistance decreasing with more parallel rods, and proximity of rods or configuration (triangle, square, etc) a). $\alpha := \frac{B_1}{\text{Rod}_{\text{len1}}} \qquad \alpha = 0.156$ $R_2 := R \cdot \left(\frac{1 + \alpha}{2}\right)$ $R_2 = 11.773 \ \Omega \qquad 2 \text{ rods in parallel}$ b). $R_3 := \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^2)}{6 - 7 \cdot \alpha}$ $R_3 = 8.544 \ \Omega \qquad 3 \text{ rods in parallel}$ c). $R_3_{-\text{tri}} := R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_3_{-\text{tri}} := R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_3_{-\text{tri}} := R \cdot \left(\frac{1 + 2 \cdot 707 \cdot \alpha}{4}\right)$ $R_4_{-\text{sor}} := R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$	Solution:	
See the value of resistance decreasing with more parallel rods, and proximity of rods or configuration (triangle, square, etc) a). $\alpha := \frac{B_1}{\text{Rod}_{\text{len1}}} \qquad \alpha = 0.156$ $R_2 := R \cdot \left(\frac{1 + \alpha}{2}\right)$ $R_2 = 11.773 \ \Omega \qquad 2 \text{ rods in parallel}$ b). $R_3 := \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^2)}{6 - 7 \cdot \alpha}$ $R_3 = 8.544 \ \Omega \qquad 3 \text{ rods in parallel}$ c). $R_3_{-\text{tri}} := R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_3_{-\text{tri}} := R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_3_{-\text{tri}} := R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_4_{-\text{sqr}} := R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_4_{-\text{sqr}} := R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$	Using the results of Pr	oblem 1.
and proximity of rods of configuration (triangle, square, etc) a). $\alpha := \frac{B_1}{\text{Rod}_{\text{len1}}} \qquad \alpha = 0.156$ $R_2 := \text{R} \cdot \left(\frac{1+\alpha}{2}\right)$ $R_2 = 11.773 \ \Omega \qquad 2 \text{ rods in parallel}$ b). $R_3 := \frac{\text{R} \cdot (2 + \alpha - 4 \cdot \alpha^2)}{6 - 7 \cdot \alpha}$ $R_3 = 8.544 \ \Omega \qquad 3 \text{ rods in parallel}$ c). $R_{3_\text{tri}} := \text{R} \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_\text{tri}} := \text{R} \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_\text{tri}} := \text{R} \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{4_\text{sqr}} := \text{R} \cdot \left(\frac{1+2 \cdot 707 \cdot \alpha}{4}\right)$ $R_{4_\text{sqr}} := \text{R} \cdot \left(\frac{1+2 \cdot 707 \cdot \alpha}{4}\right)$ $R_{4_\text{sqr}} := \text{R} \cdot \left(\frac{1+2 \cdot 707 \cdot \alpha}{4}\right)$	See the value of resist	ance decreasing with more parallel rods,
a). $\alpha := \frac{B_1}{\text{Rod}_{\text{len1}}} \qquad \alpha = 0.156$ $R_2 := R \cdot \left(\frac{1+\alpha}{2}\right)$ $R_2 = 11.773 \ \Omega \qquad 2 \text{ rods in parallel}$ b). $R_3 := \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^2)}{6 - 7 \cdot \alpha}$ $R_3 = 8.544 \ \Omega \qquad 3 \text{ rods in parallel}$ c). $R_{3_\text{tri}} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_\text{tri}} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_\text{tri}} := 8.909 \ \Omega \qquad 3 \text{ rods in an equilateral triangle}$ d). $R_{4_\text{sqr}} := R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_\text{sqr}} := R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$		
$\alpha := \frac{B_1}{\text{Rod}_{\text{len1}}} \qquad \alpha = 0.156$ $R_2 := R \cdot \left(\frac{1 + \alpha}{2}\right)$ $R_2 = 11.773 \Omega \qquad 2 \text{ rods in parallel}$ b). $R_3 := \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^2)}{6 - 7 \cdot \alpha}$ $R_3 = 8.544 \Omega \qquad 3 \text{ rods in parallel}$ c). $R_{3_\text{tri}} := R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{3_\text{tri}} := R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{3_\text{tri}} := R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{4_\text{sqr}} := R \cdot \left(\frac{1 + 2 \cdot 707 \cdot \alpha}{4}\right)$ $R_{4_\text{sqr}} := R \cdot \left(\frac{1 + 2 \cdot 707 \cdot \alpha}{4}\right)$	a).	
$R_{1} = R \cdot \left(\frac{1+\alpha}{2}\right)$ $R_{2} = R \cdot \left(\frac{1+\alpha}{2}\right)$ $R_{2} = 11.773 \Omega$ $P_{3} := \frac{R \cdot (2+\alpha-4 \cdot \alpha^{2})}{6-7 \cdot \alpha}$ $R_{3} = 8.544 \Omega$ $R_{3} = 8.544 \Omega$ $R_{3} = R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3}_{1} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3}_{1} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3}_{2} := R \cdot \left(\frac{1+2 \cdot 2 \cdot \alpha}{4}\right)$ $R_{4}_{3} := R \cdot \left(\frac{1+2 \cdot 2 \cdot 2 \cdot \alpha}{4}\right)$ $R_{4} := 7.245 \Omega$ $A rods in a square$	$a = B_1$	-0 156
$R_{2} := R \cdot \left(\frac{1+\alpha}{2}\right)$ $R_{2} = 11.773 \Omega \qquad 2 \text{ rods in parallel}$ b). $R_{3} := \frac{R \cdot (2+\alpha-4 \cdot \alpha^{2})}{6-7 \cdot \alpha}$ $R_{3} = 8.544 \Omega \qquad 3 \text{ rods in parallel}$ c). $R_{3_\text{tri}} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_\text{tri}} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_\text{tri}} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{4_\text{sqr}} := R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_\text{sqr}} := R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$	$\alpha = \frac{\alpha}{\text{Rod}_{\text{len1}}} \alpha$	- 0.130
$R_{2} := R \cdot \left(\frac{1+\alpha}{2}\right)$ $R_{2} = 11.773 \Omega \qquad 2 \text{ rods in parallel}$ b). $R_{3} := \frac{R \cdot (2+\alpha-4\cdot\alpha^{2})}{6-7\cdot\alpha}$ $R_{3} = 8.544 \Omega \qquad 3 \text{ rods in parallel}$ c). $R_{3_\text{tri}} := R \cdot \left(\frac{1+2\cdot\alpha}{3}\right)$ $R_{3_\text{tri}} := R \cdot \left(\frac{1+2\cdot\alpha}{3}\right)$ $R_{3_\text{tri}} := R \cdot \left(\frac{1+2\cdot\alpha}{3}\right)$ $R_{4_\text{sqr}} := R \cdot \left(\frac{1+2.707\cdot\alpha}{4}\right)$ $R_{4_\text{sqr}} := R \cdot \left(\frac{1+2.707\cdot\alpha}{4}\right)$		
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$R_{2} = 11.773 \Omega \qquad 2 \text{ rods in parallel}$ b). $R_{3} \coloneqq \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^{2})}{6 - 7 \cdot \alpha}$ $R_{3} = 8.544 \Omega \qquad 3 \text{ rods in parallel}$ c). $R_{3_tri} \coloneqq R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{3_tri} \coloneqq R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{3_tri} = 8.909 \Omega \qquad 3 \text{ rods in an equilateral triangle}$ d). $R_{4_sqr} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$		
b). $R_{3} \coloneqq \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^{2})}{6 - 7 \cdot \alpha}$ $R_{3} = 8.544 \Omega$ 3 rods in parallel c). $R_{3_tri} \coloneqq R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{3_tri} = 8.909 \Omega$ 3 rods in an equilateral triangle d). $R_{4_sqr} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$	R ₂ = 11.773 Ω	2 rods in parallel
b). $R_{3} \coloneqq \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^{2})}{6 - 7 \cdot \alpha}$ $R_{3} \equiv 8.544 \ \Omega \qquad 3 \text{ rods in parallel}$ c). $R_{3_tri} \coloneqq R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{3_tri} \equiv 8.909 \ \Omega \qquad 3 \text{ rods in an equilateral triangle}$ d). $R_{4_sqr} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$		
$R_{3} \coloneqq \frac{R \cdot (2 + \alpha - 4 \cdot \alpha^{2})}{6 - 7 \cdot \alpha}$ $R_{3} = 8.544 \ \Omega$ $R_{3} = 8.544 \ \Omega$ $R_{3_tri} \coloneqq R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{3_tri} \coloneqq R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{3_tri} = 8.909 \ \Omega$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$	b).	
$R_{3} := \frac{1}{6 - 7 \cdot \alpha}$ $R_{3} = 8.544 \Omega$ $3 \text{ rods in parallel}$ c). $R_{3_tri} := R \cdot \left(\frac{1 + 2 \cdot \alpha}{3}\right)$ $R_{3_tri} = 8.909 \Omega$ $3 \text{ rods in an equilateral triangle}$ d). $R_{4_sqr} := R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} := R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} := R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$	$\mathbf{R} \cdot (2 + \alpha - 4 \cdot \mathbf{r})$	α^2
$R_{3} = 8.544 \Omega$ $R_{3} = 8.544 \Omega$ $R_{3_tri} \coloneqq R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_tri} \equiv 8.909 \Omega$ $3 \text{ rods in an equilateral triangle}$ $d).$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$	$R_3 \coloneqq \frac{6-7 \cdot \alpha}{6}$	
$R_{3} = 8.544 \Omega$ $3 \text{ rods in parallel}$ c). $R_{3_\text{tri}} \coloneqq R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_\text{tri}} = 8.909 \Omega$ $3 \text{ rods in an equilateral triangle}$ d). $R_{4_\text{sqr}} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_\text{sqr}} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$		
c). $R_{3_tri} := R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_tri} = 8.909 \Omega$ 3 rods in an equilateral triangle d). $R_{4_sqr} := R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} := 7.245 \Omega$ 4 rods in a square	$R_{2} = 8.544 \Omega$	3 rods in parallel
c). $R_{3_tri} \coloneqq R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_tri} = 8.909 \Omega$ 3 rods in an equilateral triangle d). $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$		
$R_{3_tri} \coloneqq R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_tri} = 8.909 \Omega \qquad 3 \text{ rods in an equilateral triangle}$ d). $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$	c).	
$R_{3_tri} \coloneqq R \cdot \left(\frac{1+2 \cdot \alpha}{3}\right)$ $R_{3_tri} = 8.909 \Omega \qquad 3 \text{ rods in an equilateral triangle}$ d). $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$	(1.)	
$R_{3_{tri}} = 8.909 \Omega$ $3 \text{ rods in an equilateral triangle}$ $d).$ $R_{4_{sqr}} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_{sqr}} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_{sqr}} \coloneqq R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$	$R_{3_{tri}} = R \cdot \left(\frac{1+2 \cdot \alpha}{2} \right)$	
$R_{3_{tri}} = 8.909 \Omega$ 3 rods in an equilateral triangle d). $R_{4_{sqr}} := R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_{sqr}} := 7.245 \Omega$ 4 rods in a square	(3	
$R_{3_{tri}} = 8.909 32$ 3 rods in an equilateral triangle d). $R_{4_{sqr}} := R \cdot \left(\frac{1 + 2.707 \cdot \alpha}{4}\right)$ $R_{4_{sqr}} := 7.245 \Omega$ 4 rods in a square		
d). $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_=} 7.245 \Omega \qquad 4 \text{ rods in a square}$	R _{3_tri} = 8.909 3 2	3 rods in an equilateral triangle
$R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$	d)	
$R_{4_sqr} \coloneqq R \cdot \left(\frac{1+2.707 \cdot \alpha}{4}\right)$ $R_{4_sqr} \coloneqq 7.245 \ \Omega$ 4 rods in a square	u).	
$\mathbf{R}_{4} = 7.245 \mathbf{\Omega} \qquad 4 \text{ rods in a square}$	$R_{1} = R \cdot \frac{1+2.70}{1+2.70}$	$07 \cdot \alpha$
$R_{i} = 7.245 \Omega$ 4 rods in a square		
	$R_{4 \text{ orr}} = 7.245 \Omega$	4 rods in a square

Pro	bblem 3:
A v (sa Fin a). b). c).	vire of length 3m and radius 0.25cm is buried in a soil of resistivity 100 ohm-m ndy clay mixture soil). d the earthing resistance when wire is buried at surface of earth wire is buried at 0.5m depth wire is buried at infinite depth
Sol	ution:
Ro	$d_{lon2} := 3 \text{ m}$ Rod $d_{lon2} := 0.0025 \text{ m}$ $\rho_{coll2} := 100 \text{ ohm} \cdot \text{m}$
a)	
uj.	$R_{surface} \coloneqq \left(\frac{\rho_{soil3}}{\pi \cdot Rod_{len3}}\right) \cdot \left(In\left(\frac{2 \cdot Rod_{len3}}{Rod_{dia3}}\right) - 1\right)$
	R _{surface} = 71.972 <i>Ω</i>
b).	
	h ₃ ≔0.5 m
	$R_{h05m} \coloneqq \left(\frac{\rho_{soi13}}{\pi \cdot Rod_{len3}}\right) \cdot \left(In\left(2 \cdot \frac{Rod_{len3}}{\sqrt{2 \cdot Rod_{dia3} \cdot h_3}}\right) - 1\right)$
	$R_{h05m} = 40.187 \ \Omega$
c).	
Wł	nen cable is buried at infinite depth, the resistance is half of the value at surface
R _{ir}	$finite3 := \frac{R_{surface}}{2}$
R _{ir}	finite ₃ = 35.986 Ω
No	te: The resistance keeps decreasing as the depth increases.

Comorato	
Concrete (encased electrodes (ground rod).
General N	olies.
1. Concret	e is hygroscopic (absorbs moisture)
2. Durieu i	ty of 20,00 Obm m
1 in modi	um and high restivity soil an electrode buried in concrete has a lower
resistar	an and high restrictly son an electrode durectly buried in earth
5 splitting	t of concrete may occur due to corrosion
6 passage	of bigh fault current may vaporise the moisture in the concrete leading
to split	ting
7. it shoul	d be used in conjunction with a grid mesh or earthing system, so as to split
the hig	h fault current, lessening the cause for splitting
8. it requi	res proper installation method (making the concrete shell, fitting the
electro	de in it , and proper connection point, etc)
Find the e	arthing resistance of a concrete encased electrode:
Given the	following data:
pc Resistiv	vity of concrete - 75 ohm-m
ps Resistiv	vity of soil - 100 ohm-m (sandy clay)
I Length	of electrode - 3m
d Diame	ter of electrode - 2cm
D D!	
Diame	ter of concrete shell - 20cm
Diame	ter of concrete shell - 20cm
$\rho_{conc} \coloneqq 75$	ter of concrete shell - 20cm
$\rho_{\rm conc} \coloneqq 75$ $\rho_{\rm s} \coloneqq 100$ o	ter of concrete shell - 20cm ohm•m hm•m
$\rho_{conc} := 75$ $\rho_{s} := 100 \text{ o}$ l := 3 m	ter of concrete shell - 20cm ohm•m hm•m
$\rho_{conc} := 75$ $\rho_{s} := 100 \text{ o}$ l := 3 m d := 0.02 n	ter of concrete shell - 20cm ohm·m hm·m
D Diame $\rho_{conc} := 75$ $\rho_{s} := 100 \text{ o}$ l := 3 m d := 0.02 m D := 0.2 m	ter of concrete shell - 20cm
$\rho_{conc} := 75$ $\rho_{s} := 100 \text{ o}$ l := 3 m d := 0.02 m D := 0.2 m	ter of concrete shell - 20cm
D Diame $\rho_{conc} := 75$ $\rho_{s} := 100 \text{ o}$ i := 3 m d := 0.02 m D := 0.2 m	ter of concrete shell - 20cm ohm · m hm · m = $\frac{1}{(a_1 + ln(D)) + a_2 \cdot (ln(8 \cdot l - 1)))}$
D Diame $\rho_{conc} := 75$ $\rho_{s} := 100 \text{ o}$ l := 3 m d := 0.02 m D := 0.2 m $R_{cEnc_rod} :=$	ter of concrete shell - 20cm ohm · m hm · m = $\frac{1}{2 \cdot \pi \cdot I} \cdot \left(\rho_{\text{conc}} \cdot \ln\left(\frac{D}{d}\right) + \rho_{s} \cdot \left(\ln\left(\frac{8 \cdot I}{D} - 1\right) \right) \right)$
D Diame $ \rho_{conc} := 75 $ $ \rho_s := 100 \text{ o} $ i := 3 m d := 0.02 m D := 0.2 m $ R_{cEnc_rod} := 100 \text{ o} $	ter of concrete shell - 20cm ohm·m hm·m = $\frac{1}{2 \cdot \pi \cdot 1} \cdot \left(\rho_{\text{conc}} \cdot \ln\left(\frac{D}{d}\right) + \rho_{s} \cdot \left(\ln\left(\frac{8 \cdot 1}{D} - 1\right) \right) \right)$
D Diame $\rho_{conc} := 75$ $\rho_{s} := 100 \text{ o}$ l := 3 m d := 0.02 m $R_{cEnc_rod} :=$ R =	ter of concrete shell - 20cm ohm · m hm · m $= \frac{1}{2 \cdot \pi \cdot l} \cdot \left(\rho_{\text{conc}} \cdot \ln\left(\frac{D}{d}\right) + \rho_{\text{s}} \cdot \left(\ln\left(\frac{8 \cdot l}{D} - 1\right) \right) \right)$ $= 34.516.0$ This resistance is lower compared to almost similar
D Diame $\rho_{conc} := 75$ $\rho_s := 100 \text{ o}$ l := 3 m d := 0.02 m $R_{cEnc_rod} :=$ $R_{cEnc_rod} =$	ter of concrete shell - 20cm ohm · m hm · m = $\frac{1}{2 \cdot \pi \cdot 1} \cdot \left(\rho_{\text{conc}} \cdot \ln \left(\frac{D}{d} \right) + \rho_{\text{s}} \cdot \left(\ln \left(\frac{8 \cdot 1}{D} - 1 \right) \right) \right)$ = 34.516 Ω This resistance is lower compared to almost similar installation conditions in previous problems
D Diame $\rho_{conc} \coloneqq 75$ $\rho_s \coloneqq 100 \text{ o}$ $i \coloneqq 3 \text{ m}$ $d \coloneqq 0.02 \text{ m}$ $D \coloneqq 0.2 \text{ m}$ $R_{cEnc_rod} \coloneqq$ $R_{cEnc_rod} \equiv$	ter of concrete shell - 20cm ohm · m hm · m $= \frac{1}{2 \cdot \pi \cdot I} \cdot \left(\rho_{\text{conc}} \cdot \ln\left(\frac{D}{d}\right) + \rho_{\text{s}} \cdot \left(\ln\left(\frac{8 \cdot I}{D} - 1\right) \right) \right)$ 34.516 Ω This resistance is lower compared to almost similar installation conditions in previous problems.
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