YTU Physics Department 2023-2024 Spring Semester		Exam Date: 15.03.2024	Exam Duration: 100 min.
FIZ1002 PHYSICS-2 Midterm Exam I		The 9th article of Student Disciplinary Regulations of YÖK Law No.2547 states ***"Cheating or helping to cheat or attempt to cheat in exams"*** de facto perpetrators take **one or two semesters suspension** penalty. Students are **NOT** permitted to bring **calculators, mobile phones**, **smart watches** and/or any other unauthorised electronic devices into the exam room.	
Question Sheet	**A A A A A**		
Name Surname			
Registration No			
Physics Group No			
Department			
Exam Hall		**Student Signature:**	
Lecturer's Name Surname			

$k = 1/(4\pi\varepsilon_0) = 9\times10^9$ (Nm²/C²)

$\vec{F}=k\frac{q_1q_2}{r^2}\hat{r}$ $\vec{E}=k\frac{q}{r^2}\hat{r}$ $\vec{E}=k\int\frac{dq}{r^2}\hat{r}$ $V=k\frac{q}{r}$

$V=k\int\frac{dq}{r}$ $V(\infty)=0$ $\Delta U=q\Delta V$ $\lambda=\frac{Q}{L}$ $\lambda=\frac{dq}{dl}$

$\sigma=\frac{Q}{A}$ $\sigma=\frac{dq}{dA}$ $\rho=\frac{Q}{V}$ $\rho=\frac{dq}{dV}$ $\phi_E=\int\vec{E}.d\vec{A}$

$V_B-V_A=-\int_A^B\vec{E}.d\vec{l}$ $\oint\vec{E}.d\vec{A}=\frac{Q_{in}}{\varepsilon_0}$

$|\Delta V|=Ed$ $E=\frac{\sigma}{2\varepsilon_0}$ $dV=4\pi r^2dr$ $dV=2\pi lrdr$

$\vec{E}(x,y,z)=-\frac{\partial V(x,y,z)}{\partial x}\hat{\imath}-\frac{\partial V(x,y,z)}{\partial y}\hat{\jmath}-\frac{\partial V(x,y,z)}{\partial z}\hat{k}$

$\frac{1}{C_{eq}}=\sum_i\frac{1}{C_i}$ $C_{eq}=\sum_i C_i$ $U=\frac{1}{2}CV^2$ $C=\frac{|Q|}{|\Delta V|}$ $C=\kappa C_0$ $C=\frac{\varepsilon_0 A}{d}$

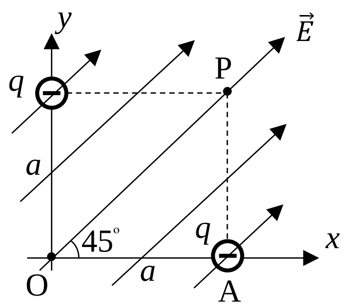
$p=aq$ $\vec{\tau}=\vec{p}\times\vec{E}$ $U=-\vec{p}.\vec{E}$ $V=\frac{V_0}{\kappa}$ $E=\frac{E_0}{\kappa}$ $U=\frac{U_0}{\kappa}$

$W=\int\vec{F}.d\vec{r}$ $W_{Elec.For.}=-\Delta U$ $U=\frac{1}{2}\sum_{i\neq j}k\frac{q_iq_j}{r_{ij}}$

$I=\frac{dq}{dt}$ $I=nqv_dA$ $R=\rho\frac{\ell}{A}$ $\vec{J}=\sigma\vec{E}$ $R=\frac{\Delta V}{I}$ $\sigma=\frac{1}{\rho}$ $J=\frac{I}{A}$

Questions 1-2 Point charges of $q=-2\times10^{-9}$ (C), located in $E=\frac{2}{\sqrt{2}}$ (V/m) uniform electric field are fixed to the two corners of the square with $a=0.5$ (m) edge as in the figure. ($cos45^\circ=sin45^\circ=\sqrt{2}/2$)

1) Find the electric field vector at point O.

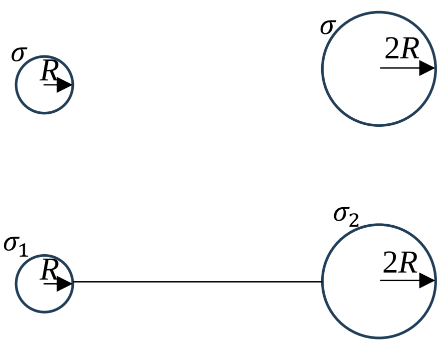


A) $72(\hat{\imath}+\hat{\jmath})$ **B)** $73(\hat{\imath}+\hat{\jmath})$ **C)** $72(\hat{\imath}-\hat{\jmath})$ **D)** $73(\hat{\imath}-\hat{\jmath})$ **E)** $72(-\hat{\imath}+\hat{\jmath})$

2) If the total electric potential is $V_O=-136$ (V) at the O point, find the potential of V_P at the corner of the square at point
P in Volts.

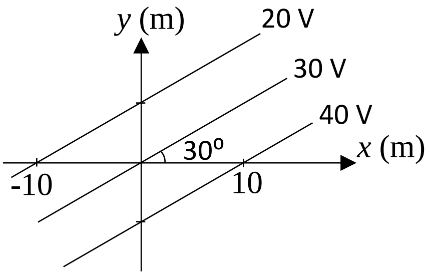
A) -135 **B)** -137 **C)** -138 **D)** -142 **E)** -124

Question 3) Two isolated metallic spheres of radii R and $2R$ are charged such that both have same charge density σ. These spheres are located far away from each other as shown in the figure and connected by a thin conducting wire. Find the new charge density on the bigger sphere in terms of σ in electrostatic equilibrium.



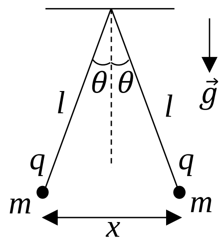
A) $\frac{2}{3}\sigma$ **B)** $\frac{3}{2}\sigma$ **C)** $\frac{5}{4}\sigma$ **D)** $\frac{5}{6}\sigma$ **E)** $\frac{7}{3}\sigma$

Question 4) Equipotential surfaces in a region are given as shown in the figure. In this region, find the electric field vector on the *xy*-plane in (V/m). $(cos30^{\circ} = \sqrt{3}/2 \quad sin30^{\circ} = 1/2)$



A) $-2\sqrt{3}\hat{\imath} + \hat{\jmath}$ **B)** $2\sqrt{3}\hat{\imath} - \hat{\jmath}$ **C)** $-2\hat{\imath} + \sqrt{3}\hat{\jmath}$ **D)** $3\sqrt{3}\hat{\imath} - \hat{\jmath}$ **E)** $-\hat{\imath} + \sqrt{3}\hat{\jmath}$

Question 5) LABORATORY QUESTION As shown in the figure, two identical very small balls of mass *m* and charge *q* are suspended by very thin silk strings having length *l*. If θ is a very small angle in the figure, find the distance *x* between the balls for equilibrium.



A) $\left(\frac{q^2 l}{4\pi\varepsilon_0 mg}\right)^{\frac{1}{2}}$ **B)** $\left(\frac{q^2 l}{\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$ **C)** $\left(\frac{q^2 l}{2\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$ **D)** $\left(\frac{2q^2 l}{\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$ **E)** $\left(\frac{q^2 l}{2\pi\varepsilon_0 mg}\right)^{\frac{1}{2}}$

Questions 6-7 An electric dipole of length 4 cm and charges of $\pm 8 \times 10^{-9}$C experiences of torque of $4\sqrt{3}$ (Nm), when placed in a uniform electric field with its axis making an angle 60º.

6) Find the magnitude of the electric field in (N/C).

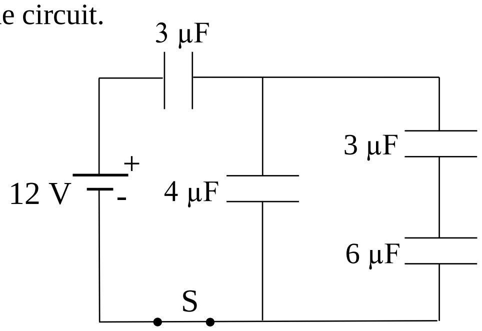
A) 2.5×10^{10} **B)** 32×10^{10} **C)** 3×10^{9} **D)** 4.5×10^{10} **E)** 28×10^{9}

7) Find the potential energy of the dipole.

A) 4 J **B)** -6 J **C)** 5 J **D)** - 4 J **E)** 6 J

Questions 8-9-10 Capacitors that were initially uncharged are connected as in the circuit.

8) Find the equivalent capacitance of the circuit in µF.



A) 1 **B)** 2 **C)** 3 **D)** 4 **E)** 5

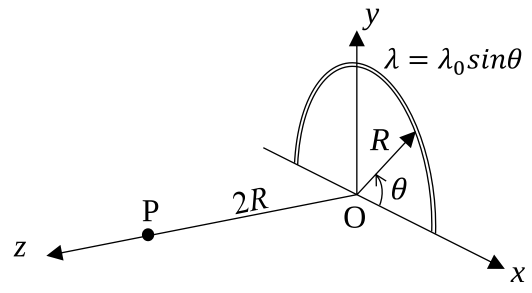
9) With the S switch closed, find the charge on the 6 (µF) capacitor in µC.

A) 4 **B)** 16 **C)** 24 **D)** 8 **E)** 12

10) Now, switch S is opened and a material with a dielectric constant of $\kappa = 2$ is put into the 6 (µF) capacitor. In this case, find the potential difference across the 4 (µF) capacitor in Volts.

A) 2.25 **B)** 2.5 **C)** 3.25 **D)** 3.5 **E)** 3.75

Questions 11-12-13 As shown in the figure, for the semicircle with radius R and with $\lambda = \lambda_0 sin\theta$ charge density on the xy-plane;



11) Calculate the z-component (E_z) of the electric field vector at point P, which is 2R away from point O on the z-axis.

A) $\frac{k\lambda_0}{\sqrt{5}R}$ **B)** $\frac{3k\lambda_0}{5\sqrt{5}R}$ C) $\frac{4k\lambda_0}{5\sqrt{5}R}$ **D)** $\frac{2k\lambda_0}{5\sqrt{5}R}$ **E)** $\frac{k\lambda_0}{5\sqrt{5}R}$

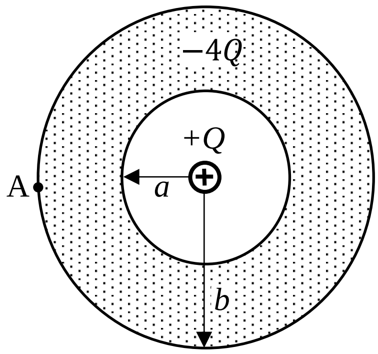
12) Find the total amount of charge on the semicircle.

A) $6\lambda_0 R$ **B)** $3\lambda_0 R$ **C)** $4\lambda_0 R$ **D)** $5\lambda_0 R$ E) $2\lambda_0 R$

13) When a point charge $+Q$ is moved from infinity to point P, find the change in the potential energy of that charge. $(V(\infty) = 0)$

A) $\frac{2kQ\lambda_0}{\sqrt{5}}$ **B)** $\frac{4kQ\lambda_0}{5\sqrt{5}}$ **C)** $\frac{3kQ\lambda_0}{2\sqrt{5}}$ **D)** $\frac{kQ\lambda_0}{\sqrt{5}}$ **E)** $\frac{2kQ\lambda_0}{5\sqrt{5}}$

Questions 14-15 The $-4Q$ charge is uniformly distributed in the insulating spherical slice with an inner radius a and outer radius b. At the center of the spherical slice is the point charge with $+Q$ charge.



14) Find the electric potential of point A that is at the $r = b$ relative to a point at the infinity. $(V(\infty) = 0)$

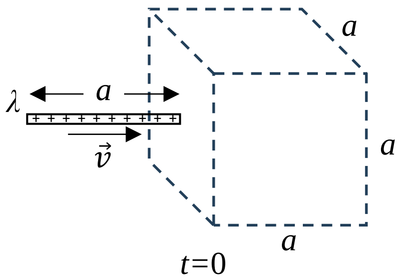
A) $-k\frac{4Q}{b}$ **B)** $-k\frac{5Q}{b}$ C) $-k\frac{3Q}{b}$ **D)** $k\frac{Q}{b}$ **E)** $k\frac{2Q}{b}$

15) Find the distance r where the electric field is zero.

A) $\left(\frac{b^3+3a^3}{4}\right)^{\frac{1}{3}}$ **B)** $\left(\frac{b^3-a^3}{4\pi}\right)^{\frac{1}{3}}$ **C)** $\left(\frac{b^3-a^3}{4}\right)^{\frac{1}{3}}$ **D)** $\left(\frac{b^3+3a^3}{4\pi}\right)^{\frac{1}{3}}$ **E)** $\left(\frac{2b^3+3a^3}{4}\right)^{\frac{1}{3}}$

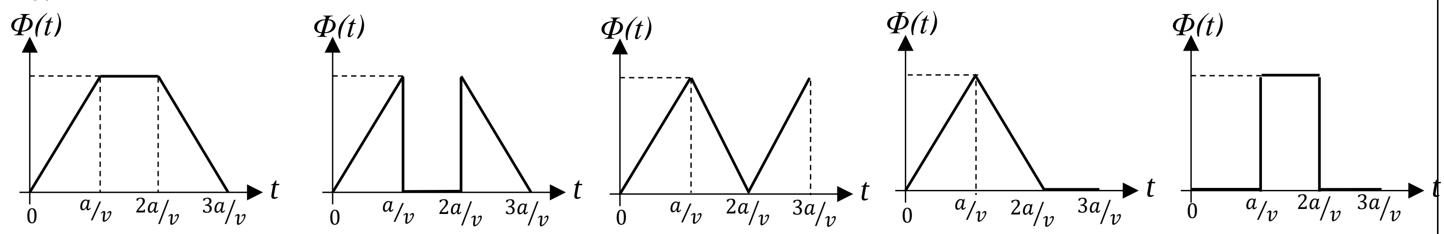
Questions 16-17 In the figure, an imaginary cube with edge a is shown with a dashed line. A rod of length a with uniform charge density λ moves towards right a constant speed v. At $t = 0$, the rigth end of the rod just touches the left face of the cube.

16) Find the maximum value of the electric flux passing through the surface of the cube during the movement of the charged rod.



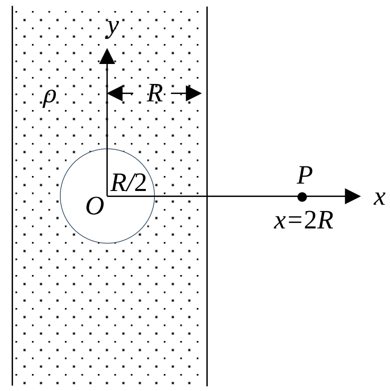
A) $\frac{\lambda a}{6\varepsilon_0}$ **B)** $\frac{6\lambda a}{\varepsilon_0}$ **C)** $\frac{\lambda a}{\varepsilon_0}$ **D)** $\frac{\lambda}{\varepsilon_0}$ **E)** $\frac{\lambda a}{3\varepsilon_0}$

17) Which of the following represents the correct graph between electric flux passing through the surface of the cube with time?



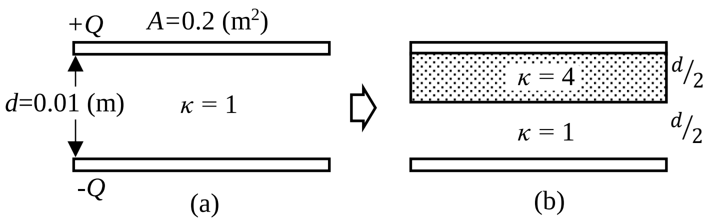
A) **B)** **C)** **D)** **E)**

Question 18) An infinitely long cylinder of radius R has a uniform charge density ρ. As shown in the figure, there is a spherical cavity of radius $R/2$ inside the cylinder with its center on the major axis of the cylinder. Find the magnitude of the electric field at the point P, which is at a distance $2R$ from the axis of the cylinder.



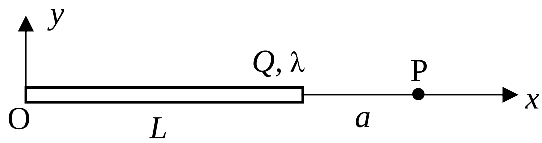
A) $\frac{23\rho R}{96\varepsilon_0}$ **B)** $\frac{\rho R}{36\varepsilon_0}$ **C)** $\frac{3\rho R}{46\varepsilon_0}$ **D)** $\frac{18\rho R}{83\varepsilon_0}$ **E)** $\frac{\rho R}{96\varepsilon_0}$

Question 19) A parallel plate capacitor in figure (a) is charged under the 100 (V) potential difference. Then, half the volume of this charged capacitor is filled with insulating dielectric material as in figure (b).
Find the magnitude of the electric field in the dielectric material that has dielectric constant $\kappa = 4$.



A) 1500 (V/m) **B)** 3500 (V/m) **C)** 2000 (V/m) **D)** 3000 (V/m) **E)** 2500 (V/m)

Question 20) A rod of length L and charge Q has a uniform charge density of λ, lies along the x-axis, as shown in the figure. Which of the following expression gives the electric field vector at the point P which is at a distance of a from the right end of the rod?



A) $-\frac{k}{L}\int_0^L \frac{Qdx}{(a+x)^2}\hat{\imath}$ **B)** $k\lambda\int_0^L \frac{adx}{(L+a)^2}\hat{\imath}$ **C)** $\frac{k}{L}\int_0^L \frac{Qdx}{(L+a-x)^2}\hat{\imath}$ **D)** $k\lambda\int_0^L \frac{adx}{(L-x)^2}\hat{\imath}$ **E)** $-\frac{k}{L}\int_0^L \frac{Qdx}{(L-a-x)^2}\hat{\imath}$