<u>TRUE-FALSE STATEMENTS:</u>

<u>ELECTRICITY:</u>

1. Electric field lines originate on negative charges.
2. The flux of the electric field over a closed surface is proportional to the net charge enclosed by the surface.
3. Electric flux is a scalar quantity.
4. In electrostatics the charge density is constant on the surface of a metal.
5. In electrostatics the surface of a metal is an equipotential surface.
6. In electrostatics the electric potential is constant inside a sphere.
7. Electric potential is the product of the electric field and the distance.
8. The flux of the electric field over a closed surface cannot be negative.
9. According to Gauss' law, if the radius of the sphere surrounding a point charge is doubled, the electric flux over the sphere increases by a factor of four.
10. In dielectrics, susceptibility is proportional to the electric field.
11. The tangential component of the electric field is unchanged at an interface between two dielectrics.
12. The capacitance of a capacitor is inversely proportional to the applied voltage.
13. The energy stored in a capacitor is proportional to the voltage across the electrodes.
14. Electric dipole moment is a vector that points from the negative charge to the positive charge.

<u>MAGNETISM:</u>

1. According to Biot-Savart's law the magnetic field **B** is parallel to the current element that creates it.
2. According to Biot-Savart's law the magnetic field **B** is inversely proportional to the square of the distance from the current element.
3. If the net current across a surface bounded by a closed loop is zero then there is no magnetic field anywhere along the loop.
4. The line integral of the magnetic field strength **H** can be negative.
5. In paramagnetic materials the magnetic susceptibility is negative.
6. Paramagnetic materials cannot be gases or liquids.
7. A paramagnetic material loses its paramagnetism above the Curie temperature.
8. Displacement current can create a magnetic field that is constant in time.
9. The direction of eddy currents in metals is governed by Lenz's law.
10. Mutual inductance depends on the applied current.
11. According to Faraday's law of induction, a voltage can only be induced if the magnetic field **B** changes in time.
12. Inductance is proportional to the current that creates the magnetic flux in the inductor.
13. The energy density of a magnetic field in vacuum is proportional to the square of the magnetic field.

<u>OPTICS:</u>

1. In Young's double slit experiment, when the illumination is white light, the higher-order fringes are in color.

2. In Young's double slit experiment, when the illumination is white light, the zero-order fringe is in color.
3. When light is reflected on an optically denser medium, it undergoes a phase change of 180°.
4. The resolution of a diffraction grating depends on the number of illuminated lines.
5. The resolution of an astronomical telescope is independent of the observed wavelength.
6. According to Fermat's principle, light propagates along a straight line even in an inhomogeneous medium.
7. When light travels into an optically denser medium, its wavelength decreases.
8. If completely unpolarized light hits a linear polarizer, less than 10% of the incoming intensity is let through.
9. Brewster's angle is always smaller than the limiting angle of total internal reflection.
10. Total internal reflection only happens when light travels from a dense medium into a less dense medium.
11. If a linearly polarized light beam hits an interface at Brewster's angle, the reflected light will be elliptically polarized.
12. If light travels in air and hits the surface of glass (n=1.5) at an angle of 80°, total reflection occurs.
13. At high temperatures lasers can operate purely by spontaneous emission.
14. Newton's rings can be used for testing lens surfaces.
15. Inside a calcite crystal, a point source can emit elliptical wavefronts.
16. The terms „unpolarized light" and „elliptically polarized light" describe the same phenomenon.
17. The index of refraction of a medium is the ratio between the speed of light in vacuum and the speed of light in the medium.
18. Sunlight is elliptically polarized.
19. When two linear polarizers are placed on top of each other, the total transmitted intensity can be more than 50% of the incoming intensity.
20. Population inversion can only be achieved at thermodynamic equilibrium.
21. In holography, the purpose of the reference wave is to enable us to record the phase distribution of the object wave.

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<u>MULTIPLE CHOICE PROBLEMS:</u>

<u>ELECTRICITY:</u>

1. An uncharged plastic sphere has a radius of 10cm. We place a point charge of –1mC at a distance of 1m from the center of the sphere. Find the total flux of the electric field over the surface of the plastic sphere.

(a) 1Vm (b) 0 (c) –2Vm (d) none

2. A charged particle of 16nC is placed to the North of point P, at a distance of 2m. Another charged particle, of –45nC, is placed to the East of P, at a distance of 3m. Find the electric field at point P.

(a) 58V/m (b) 16.4V/m (c) 8.8V/m (d) none

3. A long cylinder has a radius of 10cm. Find the surface charge density on the surface of the cylinder, if the electric field at a distance of 1m from the cylinder's axis is 10kV/m.
(a) 44.3nC/m^2 (b) 886nC/m^2 (c) 4.43μC/m^2 (d) none

4. A cube whose edges are 7cm long is uniformly charged with a volume charge density of 60nC/m^3. Calculate the flux of the electric field over *one side* of the cube.
(a) 1523Nm^2/C (b) 0.387Nm^2/C (c) 3.42Nm^2/C (d) none

5. Charge is distributed uniformly over the length of a circular metallic loop. The loop has a radius of 10cm. Find the charge on the loop, if the electric potential at the center of the loop is 900V relative to a point at infinity.
(a) 5nC (b) 10nC (c) 1mC (d) none

6. A cube whose edges are 7cm long is uniformly charged with a volume charge density of 60nC/m^3. Calculate the flux of the electric field over *one side* of the cube.
(a) 1523Nm^2/C (b) 0.387Nm^2/C (c) 3.42Nm^2/C (d) none

7. A charge of 3μC is distributed uniformly over the circumference of a circle having a radius of 0.2m. Find the work needed to carry a 25μC point charge from infinity to the center of the circle.
(a) 5.4J (b) 3.4J (c) 2.7J (d) none

8. A metallic sphere has a radius of 10cm. The voltage between the center of the sphere and a point 1m from the center of the sphere is 810V. Find the total charge on the sphere.
(a) 10nC (b) 21.1nC (c) 111nC (d) none

9. An infinitely long solid cylinder is given a uniform volume charge density of 2nC/m^3. The radius of the cylinder is 3cm. Find the electric field at a distance of 2cm from the cylinder's axis.
(a) 1.73N/C (b) 2.26N/C (c) 5.76N/C (d) none

10. A 100pF capacitor and a 600pF capacitor are combined in series. We put a voltage of 200V across the combination of capacitors. What is the ratio between the energy stored in the first capacitor and the energy stored in the second capacitor?
(a) 36 (b) 6 (c) 1/36 (d) none

<u>MAGNETISM:</u>

1. A proton having a speed of 50km/s is performing uniform circular motion perpendicularly a homogeneous magnetic field of 80mT. How many times does it go around the circle in 1s?
(a) $7.5\cdot10^6$ (b) $2.4\cdot10^6$ (c) $1.2\cdot10^6$ (d) none

2. A point charge of 10^{-6}C is travelling with a speed of $3\cdot10^6$m/s in a uniform magnetic field of **B** = (0.4, 0.7, 0.3) [T]. Find the magnetic force acting on the charge at the time instant when the instantanous velocity of the charge points in the +x direction.
(a) (0, −0.9, 2.1)[N] (b) (1.2, 1.4, −4)[N] (c) (0, 2.2, 0.6)[N] (d) none

3. The disk-shaped electrodes of a parallel plate capacitor have a radius of 5cm, and are separated by 1mm. The voltage between the electrodes is increasing at a rate of 1000V/s. Find the magnetic field at the edge of the capacitor.
(a) $5.5 \cdot 10^{-13}$T (b) $1.38 \cdot 10^{-13}$T (c) $2.77 \cdot 10^{-13}$T (d) none

4. A straight wire with a radius of 2mm carries a current of 10A. The surface current density is uniform over the entire cross-section of the wire. Find the magnetic field strength H at a distance of 1mm from the axis.
(a) 398A/m (b) 516A/m (c) 722A/m (d) none

5. A solenoid of length 1m carries a current of 1A. The number of turns is 1000. An iron core completely fills the solenoid. Find the relative permeability μ_r of the iron core, if the magnetic field in the solenoid is 25mT.
(a) 20 (b) 50 (c) 100 (d) none

6. A thin, solid metallic ring, having an inner radius of 6cm and an outer radius of 8cm, is rotating in a uniform magnetic field of B = 0.2T with angular velocity 10rad/s. The magnetic field is perpendicular to the plane of the ring. Find the voltage between the inner and outer edges of the ring.
(a) 1.4mV (b) 2.8mV (c) 12.6mV (d) none

7. The disk-shaped electrodes of a parallel plate capacitor have a radius of 5cm, and are separated by 1mm. The voltage between the electrodes is increasing at a rate of 1000V/s. Find the magnetic field at the edge of the capacitor.
(a) $5.5 \cdot 10^{-13}$T (b) $1.38 \cdot 10^{-13}$T (c) $2.77 \cdot 10^{-13}$T (d) none

8. In a long solenoid, whose cross sectional area is $0.4m^2$ and the number of turns is n=1500turns/meter, a time-varying current of $I(t)=(4+3t^2)$ [A] is flowing. Inside the solenoid there is smaller second solenoid, with cross sectional area $0.15m^2$ and N=300 turns. The two solenoids have a common symmetry axis. Find the voltage induced in the smaller solenoid at t=2s.
(a) 1V (b) 2.7V (c) 6.8V (d) none

9. In a solenoid having a length of 20cm the magnetic flux (the flux of the magnetic field B) is Φ_1. Next, we place an iron core of μ_r=50 inside the solenoid. The length of the iron core is 10cm, but it fills the entire cross-section of the solenoid. In this case the magnetic flux is Φ_2. Find the ratio Φ_2/Φ_1.
(a) 1.96 (b) 7.81 (c) 25 (d) none

10. A solenoid has 100 turns, a length of 10cm and a cross-sectional area of $5cm^2$. The current increases uniformly from 0 to 4A, in 0.1s. Find the induced electric field at a distance of 2cm from the axis of the solenoid.
(a) 40μV/m (b) 200μV/m (c) 320μV/m (d) none

11. A homogeneous magnetic field changes uniformly in time at a rate of 40T/s. A circular wire loop with a radius of 10cm is placed in the magnetic field, so that the plane of the wire loop is perpendicular to the field lines. Find the electric field induced in the wire loop.
(a) 1.2V/m (b) 1.6V/m (c) 2V/m (d) none

12. A circuit is made of a resistor and a capacitor so that the wire connecting them forms a circle having a radius of 1m. The capacitance of the capacitor is 10μF. The plane of the circuit is perpendicular to a uniform magnetic field which changes in time as $dB/dt=10^{-2}$T/s. Find the maximum charge on the capacitor during the process.

(a) $3.14\cdot10^{-5}$[C] (b) $6.74\cdot10^{-5}$[C] (c) $5.43\cdot10^{-4}$[C] (d) none

13. A solenoid having a cross-sectional area of 80cm^2 and 500 turns is rotating at a rate of 300rpm (revolutions per minute) in a uniform magnetic field. The axis or rotation is perpendicular to both the axis of the solenoid and the magentic field lines. The magnetic field strength is $H=10^5$A/m. Find the magnitude of the induced voltage in the solenoid at the instant when the axis of the solenoid makes an angle of 60° with the magnetic field.

(a) 13.68V (b) 7.23V (c) 2.16V (d) none

14. A 20 cm long solenoid with a cross-sectional area of 4cm^2 has 200 turns. Another coil having 50 turns is wound closely around it. Find the mutual inductance.

(a) 2μH (b) 6.2μH (c) 25.1μH (d) none

15. A long solenoid with a radius of 3cm has 1500 turns per meter. Inside this solenoid there is another, smaller solenoid whose radius is 1cm and the number of turns is 20. The axes of the two solenoids make an angle of 60°. Find the mutual inductance.

(a) 5.9μH (b) 8.5μH (c) 12.7μH (d) none

16. A square-shaped wire loop is placed at a distance of 2cm from an infinitely long straight wire. The side of the square is 10cm long. The square and the long wire are in the same plane. Find the magnetic flux through the square-shaped loop if the long straight wire carries a current of 2A.

(a) $4.2\cdot10^{-3}$ Tm^2 (b) $7.2\cdot10^{-8}$ Tm^2 (c) $6.7\cdot10^{-9}$ Tm^2 (d) none

17. We connect a 10V battery in series with a switch, a 5Ω resistor and a 10mH inductor. We close the switch and wait long enough so that the current reaches its final constant value. Find the magnetic energy of the inductor in this stationary state.

(a) 15mJ (b) 20mJ (c) 60mJ (d) none

18. A square-shaped wire loop, whose side has a length *L*, is placed at a distance of 2*L* from an infinitely long straight wire. Find the mutual inductance.

(a) $(\mu_0L/2\pi)\cdot\ln(1.5)$ (b) $(\mu_0L/2\pi)\cdot\ln(2/3)$ (c) $(\mu_0L/2)\cdot\ln(1.5)$ (d) none

<u>OPTICS:</u>

1. Find the closest wavelength that can be distinguished – according to Rayleigh's criterion – from a 600nm wavelength light beam, if the first order of a diffraction grating is used, and 600 grating lines are illuminated.

(a) 600.33nm (b) 600.5nm (c) 601nm (d) none

2. In Young's double slit experiment we observe an interference pattern with a spatial frequency of 5 lines/cm. Find the distance between the slits, if the illumination wavelength is 632nm and the screen is 2 meters away.
(a) 0.63mm (b) 1.26mm (c) 1.78mm (d) none

3. The circularly shaped radar of a ship has a diameter of 2m, and it radiates at a frequency of 15GHz. 2km away from the ship there are two small boats on the sea. How close can the two boats be to each other, so that they can still be observed as two separate objects?
(a) 10.5m (b) 24.4m (c) 45.6m (d) none

4. A spy satellite is orbiting at an altitude of 100km above the Earth's surface. Find the minimum diameter of the lens of the recording camera that is placed inside the satellite, if the satellite can distinguish Earth objects that are separated by 50cm. (λ = 500nm).
(a) 2.2cm (b) 12.2cm (c) 32.1cm (d) none

5. At what angle from the horizon is the Moon when its image reflected in calm water is linearly polarized? The refractive index of water is 1.33.
(a) 25° (b) 37° (c) 63° (d) none

6. Two polarizers are placed on top of each other. Their transmission axes make an angle α. Find this angle, if 40% of the intensity of the incoming unpolarized light is transmitted through the system.
(a) 26.6° (b) 31° (c) 38.4° (d) none

7. When two polarizers are placed on top of each other in a cross-polarized configuration, no intensity is let through. We place a third polarizer between them, so that its polarization axis makes an angle of 45° with the polarization axes of the first two polarizers. If the illumination is unpolarized light, how many % of the incoming light intensity passes through this configuration?
(a) 33.33% (b) 25% (c) 12.5% (d) non

8. Light hits an air-glass interface and is refracted into glass. The refracted ray makes an angle of 65° *with the surface*. Find the angle that the incident ray makes with the surface. (The speed of light in the glass is 200000km/s.)
(a) 23.43° (b) 32.17° (c) 50.66° (d) none

9. Calculate the ratio between (1) the power incident on a 4mm^2 surface at a distance 1 meter from a 25W light bulb, and (2) the power incident on the same surface if it is illuminated by a 1mW laser. The diameter of the laser beam is 1mm.
(a) 1/8 (b) 1/53 (c) 1/126 (d) none

10. The speed of light in water is 225000km/s. Find the limit angle of total internal reflection on a water-air interface.
(a) 48.6° (b) 65.8° (c) 78.2° (d) none

11. Find Brewster's angle at a water-glass interface if the index of refraction for water is 1.3 and the index of refraction for glass is 1.55.

(a) 20° (b) 50° (c) 80° (d) none

12. The spherical surface of a glass plano-convex lens is pushed against a flat glass surface. The radius of the spherical surface is 5m, and the index of refraction of glass is n=1.5. The arrangement is illuminated perpendicularly by a plane wave with λ=633nm and concentric interference fringes („Newton's rings") are observed. Find the radius of the 6th bright ring.
(a) 2.1mm (b) 4.2mm (c) 6.7mm (d) none

13. A single slit with a width of 1mm is illuminated with a monochromatic plane wave of λ=514nm. How far is the screen from the slit if the width of the main intensity maximum of the diffraction pattern is 1.2mm?
(a) 340cm (b) 263cm (c) 117cm (d) none

14. A single slit with a width of 0.3mm is illuminated with a laser beam of λ=633nm. Find the width of the main intensity maximum on a screen 1 meter from the slit.
(a) 0.3mm (b) 1.7mm (c) 4.2mm (d) none

15. Light having a wavelength of 600nm is incident perpendicularly on a diffraction grating. On a screen, 1 meter away from the grating, the 1st order and (−1)st order diffraction maxima are separated by a distance of 20cm. Find the grating constant.
(a) 6μm (b) 1.5μm (c) 1.2μm (d) none

16. A vertically polarized light beam is incident on two polarizers placed one after the other. The axis of the first polarizer is at 30° from the vertical and the axis of the second polarizer is 90° from the vertical. If the intensity of the incident beam is $1mW/m^2$, what is the intensity of the light beam after the polarizers?
(a) 0 (b) $0.1875mW/m^2$ (c) $0.675mW/m^2$ (d) none

17. Find the minimum angular separation of two stars that we can still discern as individual dots. Assume that the stars radiate at a wavelength of 500nm and the pupil of the eye has a diameter of 4mm.
(a) 1° (b) 150" (c) 31" (d) none

18. The light of a HeNe laser – whose wavelength is 633nm – is incident perpendicularly on a diffraction grating. The grating has 500 lines/mm. Find the angular direction of the first diffraction maximum.
(a) 62.5° (b) 43.7° (c) 18.5° (d) none

19. A light beam with a wavelength is 600nm is incident perpendicularly on a diffraction grating. On a screen 1m away from the grating the –1st order and +1st order diffraction maxima are separated by a distance of 20cm. Find the grating period.
(a) 1.2μm (b) 3μm (c) 6μm (d) none

20. Two light beams – with wavelengths of 600nm and 601nm, respectively – are incident perpendicularly on a diffraction grating. The grating constant is 2μm. Find the distance of the 2nd order diffraction maxima of the two light beams on a screen which is 2 meters away.

(a) 3.91mm (b) 5.32mm (c) 8.55mm (d) none

$c = 3 \cdot 10^8 m/s$
$\varepsilon_0 = 8.854 \cdot 10^{-12} As/Vm$
$\mu_0 = 4 \cdot \pi \cdot 10^{-7} Vs/Am$
$m_e = 9.1 \cdot 10^{-31} kg$
$m_p = 1840 \cdot m_e$