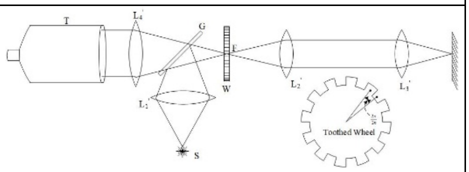
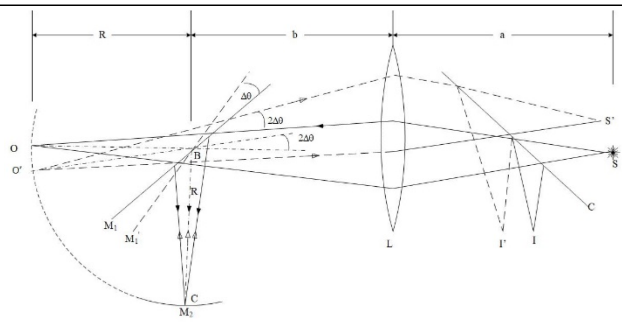
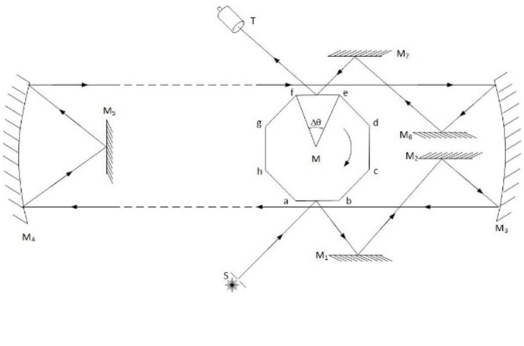
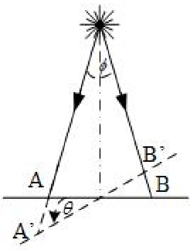
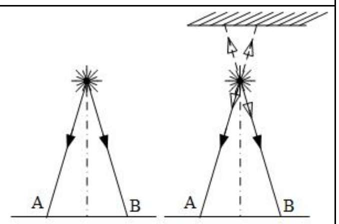
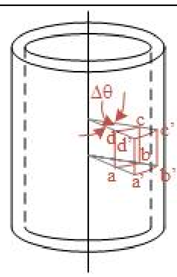
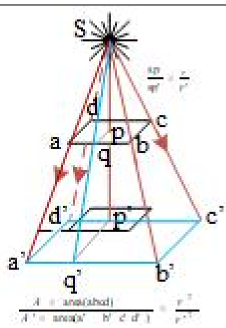
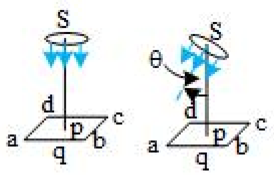
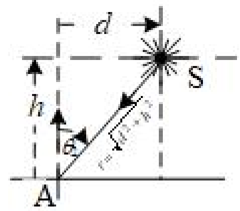
Wave and Motion: Rest of Optics – Typical Questions (Illustrations Only)

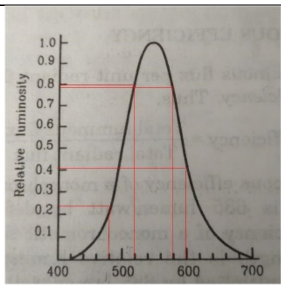
I-1	Speed of sound depends upon medium, temperature and humidity, while speed of sound is given in air without specifying any other parameter. Moreover, parameters that affect speed of sound being many, the speed in cannot be considered as a standard to define 1 meter length as, $s = v \times t \Rightarrow 1\,m = 332 \times \frac{1}{332}$ where $t = \frac{1}{332}$ s as given.
I-2	Radius of the earth 6371 km. Speed of light is about $c = 3 \times 10^8$ m/s or 3,00,000 m/s. Thus to get 10% accuracy the minimum distance between the two experimenters should be $d = \left(c \times \frac{10}{100}\right) \times \frac{1}{2} \Rightarrow d =$ **15000 km**. This distance is more than the diameter of the earth. Knowing the spherical geometry of the earth, clear visibility of both the experimenters is obstructed by the **curvature of the earth's surface**.
I-3	When toothed wheel is placed slightly away from the focal plane of the converging lens the rays become diverging and thus light would spread beyond the perimeter of the toothed wheel. As result of gradual increase of speed of toothed wheel, light pulses to flicker to blocking of image of source would not occur. Instead image of the source would be **continuously visible image of source is undesirable.**
I-4	The experimental setup in original Fizeau method is purely mechanical. Further, in the method speed of light is , in the method speed of light is $c = \frac{2D}{\frac{\pi}{n\omega}} \Rightarrow c = \frac{2D \times n\omega}{\pi} \Rightarrow c = \frac{2D \times n \times 2\pi N}{\pi} \Rightarrow c = 4DnN$. Here, D m is the distance between the toothed wheel and the mirror, n is the number of teeth in the toothed when and N rpm is speed of wheel. Thus decrease of distance from 8.6 km to 8.6 m on a scale of $^1/_{1000}$ would require speed on of toothed wheel to be increased by 1000 times and is a constraint and **not with of the mechanical systems in the experimental setup.**
I-5	Polygonal mirror which is set up in rotation in Michelson method. Angular deviation in surface of the between two adjoining mirrors $\Delta\theta = \frac{2\pi}{N}$ …(1)where N number of faces of the polygonal mirror. It translates into angular speed of polygonal mirror $\omega = \frac{\Delta\theta}{\Delta t}$ …(2). Here, $\Delta t = \frac{D}{c}$ …(3), is the time taken by light to travel distance D between the two reflections from the polygonal mirror. Accordingly, combining (1), (2) and (3) we have $\omega = \frac{\frac{2\pi}{N}}{\frac{D}{c}} \Rightarrow \omega = \frac{2\pi c}{ND} \Rightarrow c = \frac{\omega ND}{2\pi}$. Thus, increase in N helps to reduce either ω and/or D, which helps to improve upon feasibility of **accuracy of measurement.**
I-6	The speed of light $c = 3 \times 10^8$ m/s is in vacuum and is highest. Further, refraction phenomenon depends upon decrease in speed of light in a transparent medium which is obviously denser and is represented as $\mu = \frac{c}{v}$ here μ is the refractive index and v is the speed of light in the medium such that $c > v$. In the instant question, air inside closed cylindrical tube is being gradually pumped out and hence density of air would gradually reduce. Therefore, speed of light would **increase**.
I-7	Speed of light of all frequencies is same in vacuum. However, it reduces in a medium and this reduction is dependent on frequencies causing dispersion of light. Therefore, **answer is option (a).**
I-8	Image is convergence of rays from object. Thus there is a distance between object, and rays from object would will travel a distance $D = v - u$ and would take a time $t = \frac{D}{c}$ to form fresh image of object after it is displaced. Since, magnitudes $D \ll c$ and delay would be very small, which might not be perceivable. Yet, **image would be formed a little later, as provided in option (b)**

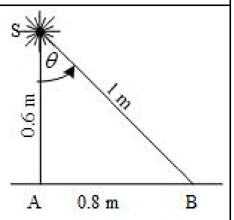
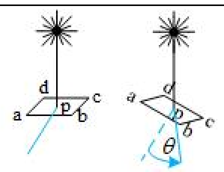
I-9	Speed of light is absolute and not relative and hence it is independent of the speed og observer be it anywhere, and hence *c* = 299,792,458 m/s in all four cases provided **in option (a), (b), (c), (d), is the answer.**
I-10	Distances required to get a reasonable accuracy are large in (a) Roemer method, (b) Fizeau method and (d) Michelson method. It was on only **Focault, in option (c),** who could perform experiment in laboratory due design of his experimental setup. Hence, **answer is Option (c).**
I-11	Performing experiment to measure speed of light in water requires short distance as required in Focault method in option (c) and it is possible to place any liquid transparent medium (be it water) in space. But, in other three methods at option (a), (b) and (d) distances are in few kilometers making them impracticable to be performed in water. Hence, **answer is option (c).**
I-12	The experimental setup in original Fizeau method is purely mechanical. Further, in the method speed of light is , in the method speed of light is $c = \frac{2D}{\frac{\pi}{n\omega}} \Rightarrow c = \frac{2D\times n\omega}{\pi} \Rightarrow c = \frac{2D\times n\times 2\pi N}{\pi} \Rightarrow c = 4DnN$. …(1). Here, $D = 12.0 \times 10^3$ m is the distance between the toothed wheel and the mirror, $n = 180$ is the number of teeth in the toothed when and N rpm is speed of wheel. Therefore, $N = \frac{c}{4Dn} \Rightarrow N = \frac{3\times10^8}{4\times(12.0\times10^3)\times180} \Rightarrow 34.7\dot{2}$. And angular speed required to ensure image us not seen is $\omega = 360 \times N = \mathbf{1.25 \times 10^4}$ **degrees/s is the answer.** 
I-13	In Focault's apparatus speed of light is $c = \frac{4R^2\omega a}{s(R+b)}$ …(1). In this $R = 16$ m is radius of the concave mirror which is equal to distance between rotating mirror and fixed mirror, ω is the angular speed of the rotating mirror such that $\omega = 2\pi N$…(2), given that $N = 356$ rpm, distance between source and lens is $a = 2$, distance between lens and rotating mirror is $b = 6$ m, and shift in the image of source is $SS' = II' = s = 7.00$ mm or $s = 7.00 \times 10^{-3}$m.  Combining (1) and (2), using given data $c = \frac{4R^2(2\pi N)a}{s(R+b)}$. It leads to $c = \frac{4\times(16)^2\times(2\pi\times356)\times2}{(7.00\times10^{-3})(16+6)} = \mathbf{2.97 \times 10^8}$ **m/s is the answer**.
I-14	In Michelson experiment speed of light $c = \frac{D\omega N}{2\pi} \Rightarrow c = \frac{D(2\pi n)N}{2\pi} \Rightarrow c = DnN$, where $D = 4.8 \times 10^3$ m is the distance travelled by light between the two reflections from octagonal mirror having $N = 8$ faces and n is the number of revolutions of polygonal mirror in rpm. Thus, using the given data required $n = \frac{c}{D\times N} \Rightarrow n = \frac{3.0\times10^8}{(4.8\times10^3)\times8} \Rightarrow n =$ 7812.5 $= \mathbf{7.8 \times 10^3}$ **revolutions per second** is the answer, using principle of SDs. 
I-15	Luminous flux in the range 380 (violet colour) nm to 750 nm (red colour) is a part of electromagnetic radiation which extends in wavelength on both the sides of the luminous flux. The radio waves gave wavelength of the order 1 mm to 1 m is of much beyond spectrum of visible flux and hence not perceived by eye. Hence luminous flux content in radio waves is zero.
I-16	Luminosity of a source of radiation depends upon on wavelength of content of luminous flux in the radiation. It is maximum at 555 nm corresponding to nearly yellow colour. Luminosity of visible spectrum

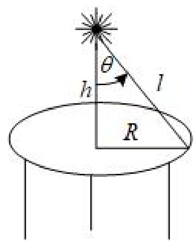
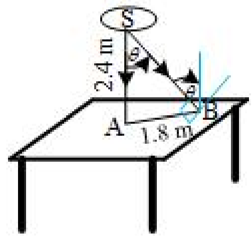
	of radiation is represented in bell shaped curve with zero luminosity for wave length lesser than 380 (violet colour) nm and greater than 750 nm (red colour) Radiation of sodium vapour lamp has frequency is 589.6 nm is within the luminous range of wavelength. Whereas, wavelength of ultra violet is less than the minimum wavelength 380 nm in the visible spectrum. Therefore, **luminosity of ultraviolet lamp, irrespective of its power, is zero** while SVL has luminosity despite its power being 1/1000 times that of ultraviolet lamp.
I-17	Illuminance caused by a light source is $A = \vec{I} \cdot \hat{n} \Rightarrow I \cos\theta$ where $\vec{I}$ is the intensity of illumination and $\hat{n}$ is the unit vector of the incident surface and θ is the angle between direction of incident light and normal to the surface of incidence. When light is incident normal to the surface $\cos\theta\|_{\theta=0} = 1$, illuminance is maximum. But, when surface is rotated i.e. $\theta > 0 \Rightarrow \|\cos\theta\| < 1$. Accordingly, on rotation of surface by an angle $\theta = 30^0$ **illuminance on the surface would decrease**.  If light of intensity I is not incident on the surface say at an angle α, not normal to the surface, then illuminance would be $A = I\cos(\alpha \pm \theta)$. Therefore, net illuminance would depend upon **(A)** direction of rotation is increments to α or decrements it, and **(B)** new **value of $\boldsymbol{\alpha \pm \theta} \rightarrow \mathbf{0^0}$ or otherwise**.
I-18	Given that a bulb hanging (vertically) on a table (horizontal) and hence incident light is normal to the surface just below the bulb. Hence, illuminance at that point is $A = \vec{I} \cdot \hat{n} \Rightarrow I \cos\theta\|_{\theta \to 0^0} = 1$ i.e. **maximum.**  Bulb, like any other source emit radiation uniformly in all directions. When a mirror is placed above the bulb such that it is facing the table, light emanating in direction vertically above the table is reflected by the mirror and increment light vertically incident on the table. Thus, **the mirror would increase the illuminance on the table.**
I-19	Light incident on the earth, in the morning and evening such that angle between the light rays and surface of the earth is nearly $\theta \to 90^0$, While at noon the angle $\theta \to 0^0$. Therefore**, brightness of light** i.e. illuminance $A = \vec{I} \cdot \hat{n} \Rightarrow I \cos\theta$ **is low in the morning and high during noon**..
I-20	Filament lamp works on principle of incandescence where part of energy is consumed in heating filament to a temperature where it starts emitting light, while mercury vapour lamp works on the principle of excitation and relaxation of molecules of mercury vapour during conduction of current through the vapour.
I-21	Property of a transparent medium is such that it transmits as well as absorbs light incident on it. The visible colour of the medium is that of the light transmitted by it. Accordingly, a yellow plastic film on a white light source of light will absorb rays of all other colours except yellow Therefore. Luminous flux emitted by ye;;ow wrapping is less that the luminous flux emitted by white source. Hence, **illuminating power of lamp will not increase.** .
I-22	Part of the radiation sense by retina is luminous, hence brightness of source sensed by eye depends only on cumulative brightness of **luminous flux entering eye as provided in option (d)., is the answer**. **Option (a)** provides for energy of radiation entering eye, which can include wavelengths beyond the visible spectrum, hence this option **is incorrect**. Discussions in respect of option (a) are true for **option (b) and (c) and both the options are incorrect.** Thus, **answer is option (a).**
I-23	Luminosity, i.e. brightness, of light is maximum for wavelength 555 nm and it reduces on either side of the wavelength in a bell-shaped curve. Given that $\lambda_A = 450$ nm, $\lambda_B = 555$ nm and $\lambda_C = 700$ nm. Thus, brightness $X_B > X_A$, $X_B > X_C$ as provided only in **option (c), is the answer**.

I-24	Luminosity of visible spectrum of radiation is represented in bell shaped curve with zero luminosity for wave length lesser than 380 (violet colour) nm and greater than 750 nm (red colour). Hence as wave length is increased from violet colour to red colour, it will increase until it reaches wavelength 555 nm of maximum brightness. Soonafter, exceeding wavelength 555 nm, luminosity would start decreasing as provided in **option (c), is the answer**.
I-25	As per the given geometry distance between the bulb and point of observation of illuminance is $r = \sqrt{1^2+1^2} = \sqrt{2}$ m and light is incident at an angle $\theta = 45^0$. Therefore, illuminance of light at the point of observation, as per Inverse Square Law is $I = \frac{F\times\cos\theta}{r^2} \Rightarrow I = \frac{40\times\cos 45^0}{(\sqrt{2})^2} \Rightarrow I = \frac{40}{2\sqrt{2}} \approx$ **14 lux, is the answer.**
I-26	Illuminance of light is determined as per Inverse square law $I = \frac{F\times\cos\theta}{r^2}$, where F is the luminous flux, θ is the angle between the direction of flux from source and normal to the surface of incidence and θ is the separation between the source and the incident surface, in the instant case it is screen. It is given that $r' \to 1.01r$, hence $I' = \frac{F\times\cos\theta}{(r')^2} \Rightarrow I' = \frac{F\times\cos\theta}{(1.01r)^2} \Rightarrow I' = \frac{F\times\cos\theta}{r^2(1+001)^2} = I(1+001)^{-2}$. … (1). Now, applying, binomial theorem $(1+001)^{-2} \approx 1 + 0.01 \times (-2) = 1 - 0.02$ …(2). Combining (1) and (2)_ $I' = 0.98\,I$, i.e. 2% decrease in illuminance as provided in **option (c), is the answer.**
I-27	Given arrangement produces an almost parallel beam, which by definition does not diverge like light from a point source. Therefore, Inverse Square Law would not apply and illuminance remains constant at $I =$ 40 lux, irrespective of distance of the wall intercepting it. Hence, **answer is option (a).**
I-28	In case of a long cylindrical light flux spreads radially and remains uniform around a cylindrical surface as shown in the figure. Flux in an angle $\Delta\theta$ through a surface abcd emanates through surface a'b'c'd'. Both the surfaces have axial length Δy = ab=a'b'. Let the surface abcd is at a radial length r from the axis of the cylindrical light source and suface a'b'c'd' is at a distance $r + \Delta r$. Hence, peripheral lengths of area abcd is $\Delta l = r\Delta\theta$ and that of a'b'c'd' is $\Delta l' = r'\Delta\theta$. Hence, areas of abcd is $\Delta A = \Delta y \times r\Delta\theta$ and of a'b'c'd' is $\Delta A' = \Delta y \times r'\Delta\theta$. Hence, for a long cylindrical source emanating F lux per meter length, light intensity at a distance r from the axis of source is $I = \frac{F\times\Delta y\Delta\theta}{\Delta y\times r\Delta\theta} = \frac{F}{r}$, and at a distance r' from the axis of source is $I = \frac{F\times\Delta y\Delta\theta}{\Delta y\times r'\Delta\theta} = \frac{F}{r'}$. Thus intensity of light by a long cylindrical source at a small distance r from the source is $I \propto \frac{1}{r}$ as provided in **option (c), is the answer.** 
I-29	Exposure required by a photographic plate is $Q = \int_0^t I dt$. If intensity of light is uniform during the interval of exposure then $Q = I\int_0^t dt \Rightarrow Q = It$…(1). As per Inverse Square Law (geometrically concept is explained in the figure) taking normal to the surface of the plate in line with incident light intensity of light from a point source at a distance r is $I \propto \frac{1}{r^2}$, therefore ratio of intensity of light at distances $r_1$and r_2 will be $\frac{I_1}{I_2} = \left(\frac{r_2}{r_1}\right)^2$ …(2) As per (1) photographic exposure $Q = I_1t_1 = I_2t_2 \Rightarrow \frac{t_2}{t_1} = \frac{I_1}{I_2}$ …(3). Combining (2) and (3), $\frac{t_2}{t_1} = \left(\frac{r_2}{r_1}\right)^2 \Rightarrow t_2 = t_1\left(\frac{r_2}{r_1}\right)^2$. Using the given data $t_2 = 3\left(\frac{10}{5}\right)^2 \Rightarrow t_2 = 3 \times 2^2 =$ **12 s as provided in option (b) is the answer.** 

I-30	Exposure required by a photographic plate is $Q = \int_0^t I dt$. If intensity of light is uniform during the interval of exposure then $Q = I\int_0^t dt \Rightarrow Q = It$...(1). As per Inverse Square Law, , intensity of light from a point source at a distance r is $I = \frac{F \cos\theta}{r^2}$ where θ is the angle between normal to the surface of the photographic plate. Keeping everything same except turning of photographic plate $I \propto \cos\theta$. Accordingly, $\frac{I_1}{I_2} = \frac{\cos\theta_1}{\cos\theta_2}$...(2).  It is given that a photographic plate initially is placed directly infront of the cylindrical tube i.e. $\theta_1 = 0^0$ per (1) photographic exposure $Q = I_1 t_1 = I_2 t_2 \Rightarrow \frac{t_2}{t_1} = \frac{I_1}{I_2}$ ...(3).Combining (2) and (3) we have $\frac{t_2}{t_1} = \frac{\cos\theta_1}{\cos\theta_2}$. It leads to $t_2 = t_1 \times \frac{\cos\theta_1}{\cos\theta_2}$. Thus exposure, when $\theta_2 = 60^0$, using the available data $t_2 = 12 \times \frac{1}{\frac{1}{2}} =$ **24 s, as provided in option (c), is the answer.**
I-31	Illuminance caused by a point source at a point at a distance r from the lamp on a surface at an angle θ with the incident rays is $I \propto \frac{\cos\theta}{r^2}$. In the instant case, let the lamp be at height h above the table. Therefore. Initially $\theta_1 = 0^0$ and hence illuminance at the table would be $I_1 \propto \frac{1}{h^2}$. When the lamp is moved along a line parallel to the surface of the table through a distance d, then distance of the lamp from the initial point A on the table would be $r = \sqrt{d^2 + h^2}$ and angle made by rays with the surface θ_2 such that $\cos\theta_2 = \frac{h}{r}$, therefore $I \propto \frac{\frac{h}{r}}{r^2} \Rightarrow I \propto \frac{h}{r^3}$. Since, is constant and hence $\boldsymbol{I \propto \frac{1}{r^3}}$**, as provided in option (c), is the answer.**  **N.B.:** Direction of a surface is determined by normal to the surface at the point under consideration.
I-32	Illuminance produced by a tube lamp is integration of the tube comprising of point sources forming it, and it is symmetrical around the tube. Points A.B and C are along a line below the tube and parallel to it. But, distance of points B and C are on symmetrical with either end and hence intensity of glow at B = C. But point A, being symmetrical to both the ends gintensity of glow $A \neq B = C$. Since distance of point A from center of the tube is less than mid point of the tube hence as per Inverse square law intensity of glow at $A > B = C$ or $\boldsymbol{B = C < A}$ **as provided in the option (d), is the answer.**
I-33	Brightness of a source of light depends upon two factors one is wavelength in the visible spectrum, it is highest 555 nm for nearly yellow colour and minimum for violet colour (380 nm) and at lower wavelength and red colour at higher wavelength (750 nm). Luminosity for wavelength below violet and above red colours is zero. Thus, **option (d) is correct**. Further, brightness for same colour depends upon rate of emission of photons, and each photon as per Planck-Einstein equation ($e = h\nu$) is an energy packet , and rate of energy emission is power of the lamp. Thus option (c), is correct. Hence, **answer is option (c) and (d).**
I-34	The question bears options each of which appears to be correct and hence they are analyzed individually – (a) As per Inverse Square Law illuminance at a point is $I \propto \frac{1}{r^2}$. Since moving or source would influence distance between source of light and wall and hence **option (a) is correct**. (b) Keeping all other parameters same illuminance at a point, as per Inverse Square Law,$I \propto \cos\theta$, here θ is the angle between plane of extended source and wall. Hence, **option (b) is correct**. (c) As per Huygens Wave Theory, a source of light emits light in all directions, hence placing a mirror facing source and wall will cause reflection of luminous flux emitted by source towards the wall. This will increase illuminance at the wall. Thus option (c) is correct. (d) Brightness of a source of light depends upon two factors one is wavelength in the visible spectrum, it is highest 555 nm for nearly yellow colour and minimum for violet colour (380 nm)

	and at lower wavelength and red colour at higher wavelength (750 nm). Luminosity for wavelength below violet and above red colours is zero. Thus, changing colour of the source towards yellow (555 nm) would increase illuminance. Thus, **option (d) is correct.** Thus, **answer is Options (a), (b), (c) and (d).**
I-35	The question by its statements requires to evaluate correctness of each option, accordingly – (a) Luminous efficiency of a source is integration of luminosity of white lamp is $Q = \int_{\lambda_v}^{\lambda_r} Id\lambda$ over wavelength of violet colour ($\lambda_v = 380$ nm) and at lower wavelength and red colour at higher wavelength ($\lambda_r = 750750$ nm). Maximum luminosity is at wave length 555 nm. Therefore, It would depend upon wavelength of monochromatic source, and not a general statement at **option (a), is incorrect.** (b) Taking the analysis at (a) above, for same power luminosity of wavelength $\lambda =$ 555 nm is greater than integral $Q = \int_{\lambda_v}^{\lambda_r} Id\lambda$, as per stipulations in this option. Hence, **option (b) is correct.** (c) Taking analysis at (b) above illuminating power of a of monochromatic lamp of wavelength $\lambda =$ 555 nm is greater than that of a white source of same power, as per stipulations in this option. Thus, **option (c) is correct.** (d) Taking forward logic at (a), analysis of statement in **option (d) is incorrect.** **Answer is option (b) and (c).**
I-36	The question by its statements requires to evaluate correctness of each option, accordingly – (a) Dimension of luminous flux is cd/sr while dimension of radiant flux is watt. Thus they are different. Hence**, option (a) is incorrect**. (b) Luminous flus has dimensions cd/sr and of luminous intensity is also cd/sr. Thus both are same. Hence**, option(b) is correct.** (c) Dimension of radiant flux has dimension is W, and that of radiant power is W. Thus the two dimensions are same. Hence, **option (c) is correct**. (d) Relative luminosity is $= \frac{\text{Luminous flux of source}}{\text{Luminous flux of a 555 nm siurce of same power}}$. Since both quantities in the numerator and denominator of the expression have same dimension Hence, the ratio is a dimensionless quantity, and it corroborates stipulation in this option. Hence, **option (d) is correct**. Thus**, answer is option (b), (c) and (d).**
I-37	Radiant flux is $= \frac{\text{Total energy emitted } (E)}{\text{Time of emission } (t)}$. Given that, $E = 45$ joules and $t = 15$ s. Radiant flux $= \frac{45}{15} = \mathbf{3}$ **W, is the answer.**
I-38	Image recorded by photographic plate is dependent upon exposure in terms of light energy which is expressed as Total light exposure (E) = [Luminous flux (lumen)] × [Time of exposure (sec)]. Hence, using given data $L_1 \times t_1 = L_2 \times t_2 \Rightarrow t_2 = \frac{L_1 \times t_1}{L_2} \Rightarrow t_2 = \frac{12 \times 10}{12} \Rightarrow t_2 = \mathbf{10}$ **s is the answer.**
I-39	Using the given graph relative luminosity corresponding to the given wavelengths are (a) 480 nm: 0.24 (b) 520 nm: 0.80 (c) 580 nm: 0.78 (d) 600 nm: 0.41. Thus answer is (a) 0.24 (b) 0.80 (c) 0.78 (d) 0.41. **N.B.:** The accuracy of answer depends upon reproduction of graph and geometrical precision 
I-40	Luminosity of wavelength 555 nm is 1.0, while that of wavelength 600 nm is 0.6. Therefore, to produce same brightness radiant flux of needed wavelength 600 nm as that produced by 120 W of 555 nm flux is $I_1 W_1 = I_2 W_2$. Here, is luminosity and is luminous power. Therefore, with the given data $1 \times 120 = 0.6 \times W_2 \Rightarrow W_2 = \frac{120}{0.6} = \mathbf{200}$ **W is the answer.**

I-41	Luminous flux of a monochromatic light source of wavelength 555 nm is 685 lumens/watt. Therefore with the given data relative luminosity is $= \frac{\text{Luminous flux of source}}{\text{Luminous flux of a 555 nm siurce of same power}} = \frac{450}{685} = 65.6\%$ say **66% is the answer.**
I-42	Given that source of light emits two wave lengths 555 nm radiant flux 40 W and 600 nm flux 30 W. Relative luminosity of 600 nm is 0.6. We know that luminous flux of a monochromatic light source of wavelength 555 nm is 685 lumens/watt. Therefore, taking each part separately - **(a)** Total radiant flux is = 40 + 30 = **70 W, is the answer of part (a)** **(b)** Total luminous flux $F = \sum(L \times I) \times P$. Here. Is L luminous efficiency of given wavelength, $I = 686$ lumen/watt is luminous flux of 555 nm source, and P is power of source for the wavelength. Hence for both the wavelengths $F = (1 \times 685) \times 40 + (0.6 \times 685) \times 30 = \mathbf{39730}$ **lumen. is the answer of part (b)** (c) Luminous capacity is $= \frac{\text{Total luminous flux}}{\text{Total input power}} = \frac{39730}{70} = 657.6$ lumen/W say 658 lumen/W **is the answer of part (c).**
I-43	We know that luminous flux of a monochromatic light source of wavelength 555 nm is 685 lumens/watt. While luminous efficiency $\frac{\text{Total luminous flux}}{\text{Total input power}} = \frac{35 \times 685}{100} = 239.75$ lumen/W, say **240 lumen/W is the answer.**
I-44	Given luminous efficiency = 60 lumen/W total luminous flux $= 31.4 \times 60 = 1884$ lumen. Hence, luminous intensity of the source $I = \frac{F}{4\pi} = \frac{1884}{4\pi} = 149.9$ cd or say **150 cd is the answer**.
I-45	Luminous intensity of the 628 lumen source is $I = \frac{F}{4\pi} = \frac{628}{4\pi} = 49.97$ cd say 50.0 cd. Therefore illuminance at $r = 1.0$ m from the source on a small area making an angle $\theta = 37^0$ is $E = \frac{I \cos\theta}{r^2} = \frac{50 \times \cos 37^0}{(1.0)^2} = \frac{50 \times 0.8}{1.0} = \mathbf{40}$ **lux is the answer**.
I-46	Illuminance at a point is $E = \frac{I \cos\theta}{r^2} \Rightarrow I = \frac{Er^2}{\cos\theta}$. Given that angle between normal and line joining the area to the point source $\theta = 0 \Rightarrow \cos 0 = 1$. Then at point A of the area $I = E_A r^2$ …(1) and point B is shifted by 0.1 m. Since, illuminance is decreasing, shifting must be away from the source. $I = E_B(r + 0.1)^2$…(2). Equating (1) and (2), $E_A r^2 = E_B(r + 0.1)^2 \Rightarrow \frac{(r+0.1)^2}{r^2} = \frac{900}{400} \Rightarrow \frac{r+0.1}{r} = \frac{30}{20} \Rightarrow \frac{r+0.1}{r} - 1 = \frac{30}{20} - 1$. It leads to $\frac{0.1}{r} = \frac{10}{20} \Rightarrow r = 0.2$ m or **20 cm is the answer.**
I-47	Illuminance at a point is $E = \frac{I \cos\theta}{r^2} \Rightarrow I = \frac{Er^2}{\cos\theta}$. Given that angle between normal and line joining the area to the point source $\theta = 0 \Rightarrow \cos 0 = 1$. Then at point A of the area $I = E_A(0.6)^2$. Given that at $E_A = 15$ lux, hence` $I = 15 \times 0.36 = 5.4$ cd. and point B, 0.8 m away from A on the table hence,$\cos\theta = \frac{0.6}{1} = 0.6$. Hence, $E_B = I\cos\theta \Rightarrow E_B = 5.4 \times 0.6 = \mathbf{3.24}$ **lux is the answer.** 
I-48	Since area which is placed perpendicular to the incident light is rotated about the incident light by an angle of $\theta = 60^0$ neither distance from the source is changing nor the angle between the area and the incident light. Hence, **illuminance will remain unchanged, is the answer.** **N.B.:** Direction of a surface is determined by normal to the surface at the point under consideration. 

I-49	 Illuminance at a point is $E=\frac{I\cos\theta}{r^2}$, here I is the luminosity of lamp, θ is the angle between direction of light and plane $r=\sqrt{h^2+R^2}$, where h is the height of the point source above he centre of the table and R is radius of the table, as shown in the figure. Accordingly, $E=\frac{Ih}{(h^2+R^2)^{\frac{3}{2}}}$ ..(1) Height of lamp for maximum illumination, applying principle of maxima in differential calculus, $\frac{dE}{dh}=0\Rightarrow\frac{d}{dh}\left(\frac{Ih}{(h^2+R^2)^{\frac{3}{2}}}\right)=0$. Applying, derivative of a quotient of a function $\frac{I\left[\frac{d}{dh}h\times(h^2+R^2)^{\frac{3}{2}}-h\times\frac{d}{dh}(h^2+R^2)^{\frac{3}{2}}\right]}{\left((h^2+R^2)^{\frac{3}{2}}\right)^2}=0\Rightarrow(h^2+R^2)^{\frac{3}{2}}-h\times\left(\frac{3}{2}(h^2+R^2)^{\frac{1}{2}}\times\frac{d}{dh}h^2\right)=0$. This resolves into$(h^2+R^2)=\frac{3}{2}h\times 2h\Rightarrow h^2+R^2=3h^2\Rightarrow R^2=2h^2\Rightarrow h=\frac{\boldsymbol{R}}{\sqrt{\boldsymbol{2}}}$ **is the answer.**
I-50	 Scattering of diffused plane light source is not uniform like a point source. It is different in different directions. Illuminance by a diffused light source is defined by **Lambert Cosine Law** according to which illuminance of the light source on a surface parallel to the surface of the diffused light source is as per Inverse Square Law $E_0=\frac{I}{r^2}$. Further, the law states that illuminance on a plane along a line at an angle θ with surface of the diffused light source is $E'=E_0\cos\theta$. But, in the instant case illuminance is required on the surface of that table which is inclined to the line joining surface of the source and point of incidence. Hence, net illuminance would be $I''=I'\cos\theta=(I_0\cos\theta)\cos\theta\Rightarrow I_0\cos^2\theta$. In the instant case for point A, $E'_{0A}=\frac{I\cos\theta_A}{(2.4)^2}$ and $\cos\theta_A=\cos 0=1$and hence $E'_{0A}=\frac{I}{(2.4)^2}=E_{0A}''$.But, for distance of point B, $E'_{0B}=\frac{I\cos\theta_B}{(2.4)^2+(1.8)^2}$ where $\cos\theta_B=\frac{2.4}{\sqrt{(2.4)^2+(1.8)^2}}$ and hence $I_{0B}''=\left(\frac{I\times 2.4}{((2.4)^2+(1.8)^2)^{\frac{3}{2}}}\right)\times\cos\theta_B$. Accordingly, $E_{0B}''=\left(\frac{I\times 2.4}{((2.4)^2+(1.8)^2)^{\frac{3}{2}}}\right)\times\left(\frac{2.4}{\sqrt{(2.4)^2+(1.8)^2}}\right)\Rightarrow E_{0B}''=\frac{I\times(2.4)^2}{((2.4)^2+(1.8)^2)^2}$. Thus, $\frac{E_{0B}''}{RI_{0A}''}=\frac{\frac{I\times(2.4)^2}{((2.4)^2+(1.8)^2)^2}}{\frac{I}{(2.4)^2}}\Rightarrow E_{0B}''=I_{0A}''\times\frac{(2.4)^4}{((2.4)^2+(1.8)^2)^2}$. Using the given data, E_{0B}=25×$\frac{(2.4)^4}{(3)^4}$⇒$E_{0B}=25\times(0.8)^4\Rightarrow E_{0B}=10.24$ or on principle of SDs $E_{0B}=$ **10 lux is the answer.**
I-51	Illuminance of a lamp at a point $I=\frac{F}{r^2}$. Illuminance at a point due to electric lamp is $I_L=\frac{F_L}{(0.8)^2}$, while illuminance at the point due to candle is $I_C=\frac{F_C}{(0.2)^2}$. Further, it is given that $I_L=I_C\Rightarrow\frac{F_L}{(0.8)^2}=\frac{F_C}{(0.2)^2}$…(1). Now lamp is covered with a paper that transmits 49% luminous flux. Therefore, $F_L'=0.49F_L$. It is required to move lens by a distance say xm such that distance of the lamp from the point is $=(0.8-x)$mt the point $I'_L=\frac{F_L'}{(0.8-x)^2}=\frac{0.49F_L}{(0.8-x)^2}$. It is also given that $I'_L=I_C\Rightarrow\frac{0.49F_L}{(0.8-x)^2}=\frac{F_C}{(0.2)^2}$…(2). Combining (1) and (2) $\frac{F_L}{(0.8)^2}=\frac{0.49F_L}{(0.8-x)^2}\Rightarrow(0.8-x)^2=0.49\times(0.8)^2\Rightarrow(0.8-x)^2=(0.7)^2\times(0.8)^2$. It leads to $0.8-x=0.7\times 0.8\Rightarrow x=0.3\times 0.8\Rightarrow x=0.24$ m or **24 cm, is the answer**.
I-52	Illuminance at photometer due to 80 cd source is $I_1=\frac{80}{d^2}$, here d is the distance of the source from photometer and is to be determined. Illuminance at photometer due to 20 cd source is $I_2=\frac{20}{(0.4)^2}$, here 0.4 m is the distance of the source from photometer. It is given that both the sources balance the illuminance at the photometer such that $I_1=I_2\Rightarrow\frac{80}{d^2}=\frac{20}{(0.4)^2}$. It leads to and is to be determined. $d^2=\frac{80}{20}\times(0.4)^2\Rightarrow d=0.8$m or **80 cm is the answer**.
I-53	Intensity of light at the rim of a tableof radius $R=\frac{4}{2}$=2 m from a 100 W bulb at a height $h=1$m, as

	shown in the figure, is given to be I_0 and as per Inverse Square Law $I_A = \frac{F\cos\theta}{\left(\sqrt{R^2+h^2}\right)^2} \Rightarrow I_A = \frac{F}{R^2+h^2} \times \frac{h}{\sqrt{R^2+h^2}} \Rightarrow I_A = \frac{hF}{(R^2+h^2)^{\frac{3}{2}}}$. Using the given data, $I_A = \frac{1F}{(2^2+1^2)^{\frac{3}{2}}} \Rightarrow I_A = \frac{F}{5\sqrt{5}} = I_0$…(1) Illuminance due to the bulb at the centre of the table $I_B = \frac{F\cos\theta_B}{h^2} \Rightarrow I_B = F\cos\theta_B$. For point B, the angle $\theta_B = 0 \Rightarrow \cos\theta_B = 1$ and hence, $I_B = F$ …(2). Combining (1) and (2), $F = I_B = 5\sqrt{5}I_0$, and this matches with the opion (d). Hence, **option (d) is the answer.**
I-54	Lux is the unit of illuminance at a surface and it matches with option (a). Hence, **answer is option (a).**
I-55	Luminous efficiency of a lamp $\eta = \frac{\phi}{p}$ …(1), while Lumnious intensity $I = \frac{\phi}{4\pi}$…(2). Combining (1) and (2) we have $\eta \times p = 4\pi \times I$. Accordingly, $p = \frac{4\pi \times I}{\eta}$. Using the given data $p = \frac{4\pi \times 35}{5} = 28\pi \Rightarrow p = 88$ W, it matches with option (b). Hence, **answer is option (b).**

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