Wave and Motion : Geometrical Optics – Typical Questions

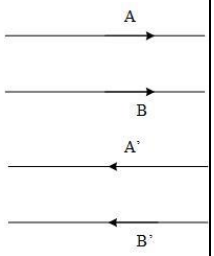
No of Questions:100 **Time Allotted: 10 Hours**

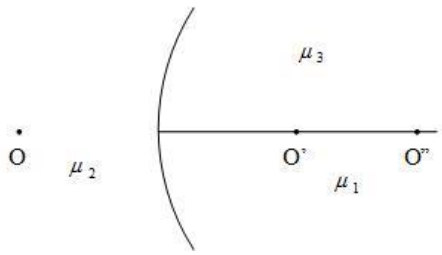
All questions are compulsory

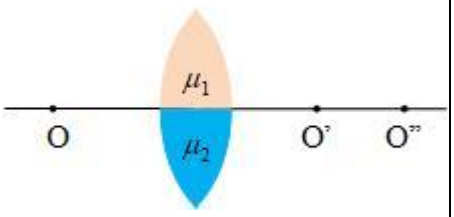
[Note: a. Figures are conceptual only and not to the scale**]**

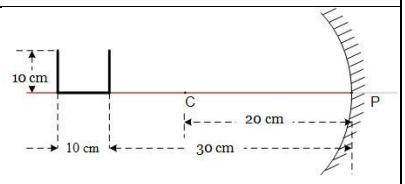
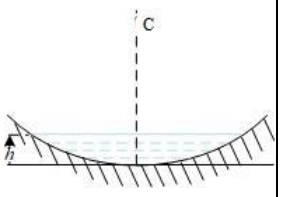
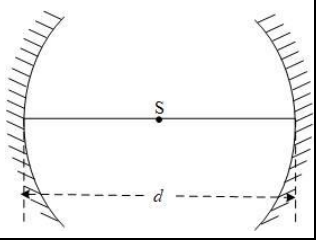
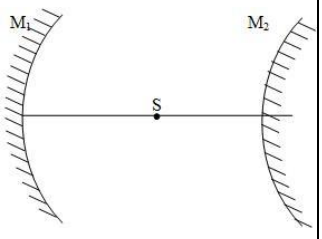
[b. Solutions may be taken up in Three parts as, Part I: 1 to 30 of Three Hours; Part II: 31 to 60 of Three Hours; Part III: 61 to 100 of Four Hour]

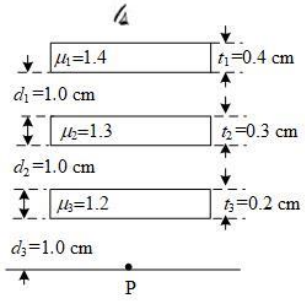
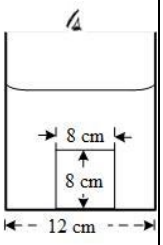
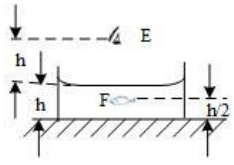
[c. It is advised to attempt question under examination conditions**]**

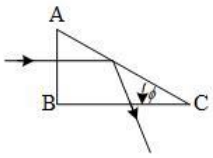
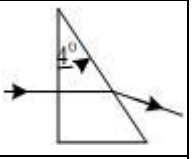
Q-01	A point source of light is placed in front of a plane mirror. (a) All the reflected rays meet at a point when produced backward (b) Only the reflected rays close to the normal meet at a point when produced backward. (c) Only the reflected ray making a small angle with the mirror, meet at point when produced backward. (d) Light of different colours make different images.
Q-02	Total internal reflection can take place only if (a) light goes from optically rarer medium (smaller refractive index) to optically denser medium (b) light goes from optically denser medium to rarer medium (c) the refractive indices of the two media are close to each other (d) the refractive indices of the two media are widely different.
Q-03	In image formation from spherical mirrors, only paraxial rays are considered because they (a) are easy to handle geometrically (b) contain most of the intensity of the incident light (c) form nearly a point of a point source to a point of image. (d) show minimum dispersion effect.
Q-04	A point object is placed at a distance of 30 cm from a convex mirror of focal length 30 cm. The image will form at (a) infinity (b) pole (c) focus (d) 15 cm behind the mirror.
Q-05	Figure shows two rays A and B being reflected by a mirror and going as A' and B'. The mirror (a) is plane (b) is convex (c) is concave (d) may be any spherical mirror 
Q-06	Image formed by a concave mirror is (a) Always real (b) Is always virtual (c) Is certainly real if the object is virtual Velocity (d) Is certainly virtual if the object is real

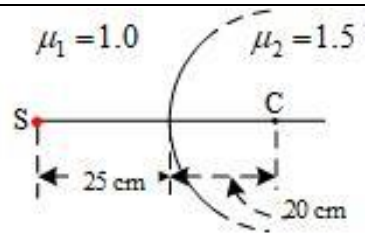
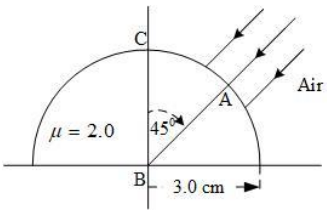
Q-07	Figure shows three transparent media of refractive indices μ_1, μ_2 and μ_3 . A point object O is placed in the medium μ_2. If the entire medium in the right of the spherical surface has refractive index μ_1 , the image at O'. If this entire medium has refractive index μ_3, the image forms at O". In this situation shown, (a) the ima"e forms between O' and O' (b) the image forms to the left of O' (c) the image forms to the right of O" (d) two images form one at O' another at O" 
Q-08	Four modifications are suggested in the lens formula to include the effect of the thickness t of the lens. Which one is likely to be correct? (a) $\frac{1}{v}-\frac{1}{u}=\frac{t}{\mu f}$ (b) $\frac{t}{v^2}-\frac{1}{u}=\frac{1}{f}$ (c) $\frac{1}{v-t}-\frac{1}{u+t}=\frac{1}{f}$ (d) $\frac{1}{v}-\frac{1}{u}+\frac{t}{uv}=\frac{t}{f}$
Q-09	A double convex lens has two surfaces of equal radii R and a refractive index $\mu = 1.5$. We have, (a) $f=\frac{R}{2}$ (b) $f=R$ (c) $f=-R$ (d) $f=2R$
Q-10	A point source of light is placed at a distance of $2f$ from a converging lens of focal length f. The intensity on the other side of the lens is maximum at a distance (a) f (b) between f and $2f$ (c) $2f$ (d) more than $2f$
Q-11	A parallel beam of light is incident on a converging lens parallel to its principal axis. As one moves away from the lens on the other side on its principal axis, intensity of light (a) Remain constant (b) continuously increases (c) continuously deceases (d) first increases then decreases
Q-12	A symmetric double convex lens is cut in two equal parts by a plane perpendicular to the principal axis. If the power of the original lens was 4D, the power of a cut lens will be (a) 2D (b) 3D (c) 4D (d) 5D
Q-13	A symmetric double convex lens is cut in two equal parts by a plane containing the principal axis. If the power of the original lens was 4D, the power of a cut lens will be (a) 2D (b) 3D (c) 4D (d) 5D
Q-14	Two concave lenses L_1 and L_2 are kept in contact with each other. If the space between the lenses is filled with a material of refractive index $\mu = 1$, the magnitude of the focal length of the combination (a) becomes undefined (b) remains unchanged (c) increases (d) decreases
Q-15	A thin lens is made of a material having refractive index $\mu = 1.5$. Both the sides are convex. It is dipped in water ($\mu = 1.33$). It will behave like (a) a convergent lens (b) a divergent lens (c) a rectangular slab (d) a prism
Q-16	A convex lens is made with a material having a refractive index 1.2. Both the surfaces of the lens are convex. If it is dipped into water ($\mu = 1.33$), it will behave like (a) a convergent lens (b) a divergent lens (c) a rectangular slab (d) a prism
Q-17	A point object O is placed on the principal axis of a convex lens of focal length $f = 20$ cm at a distance of 40 cm to the left of it. The diameter of the lens is 10 cm. An eye is placed 60 cm to the right of the lens and a distance h below the principal axis. The maximum value of h to see the image is (a) 0 (b) 2.5 cm (c) 5 cm (d) 10 cm

Q-18	The rays of different colours fail to converge at a point after going through a converging lens, This defect is called (a) Spherical aberration (b) distortion (c) coma (d) chromatic aberration
Q-19	If the light moving in a straight line bends by a small but fixed angle, it may be a case of (a) Reflection (b) refraction (c) diffraction (d) dispersion
Q-20	Mark the correct option (a) If the incident rays are converging, we have a real object. (b) Of the final rays are converging, we have a real image. (c) The image of a virtual object is called a virtual image. (d) If the image is virtual, the corresponding object is called a virtual object.
Q-21	Which of the following (referred to a spherical mirror) do (does) not depend on whether the rays are paraxial or not? (a) Pole (b) Focus (c) Radius of curvature (d) Principal axis
Q-22	The image of an extended object, placed perpendicular to the principal axis of a mirror, will be erect if (a) The object and the image are both real (b) The object and image are both virtual (c) The object is real but the image is virtual (d) The object is virtual but the image is real
Q-23	A convex lens forms a real image of a point object placed on its principal axis. If the upper half of the lens is painted black, (a) the image will be shifted downward (b) the image will be shifted upward (c) the image will not be shifted vertically (d) the intensity of the image will decrease.
Q-24	Consider three converging lenses L_1, L_2 and L_3 having identical geometrical construction. The index of refraction of L_1 and L_2 are μ_1 and μ_2 respectively. The upper half of the lens L_3 has refractive index μ_1 and lowers half of the lens has μ_2 as shown in the figure. A point object O is imaged at O' of the lens L_1 and at O" by the lens L_2 placed in same position. If L_3 is placed at the same place, (a) there will be an image at O' (b) there will be an image at O" (c) the only image will form somewhere between O' and O" (d) the only image will form away from O". 
Q-25	A screen is placed at a distance 40 cm away from an illuminated object. A converging lens is placed between the source and the screen and it is attempted to form an image of the source on the screen. If no position could be found, the focal length of the lens (a) must be less than 10 cm (b) must be greater than 20 cm (c) must not be greater than 20 cm (d) must not be less than 10 cm.
Q-26	A concave mirror of radius of curvature 40 cm is placed in front of an illuminated point source at a distance of 30 cm from it. Find position of the image.

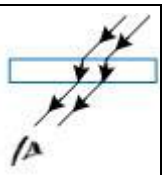
Q-27	A concave mirror forms an image of 20 cm high object on a screen placed 5.0 m away from the mirror. The height of the image is 50 cm. Find the focal length of the mirror and the distance between the mirror and the object.
Q-28	A concave mirror has a focal length of 20 cm. Find the position or positions of an object for which the image size is double of the object-size.
Q-29	A 1 cm object is placed perpendicular to the principal axis of a convex mirror of focal length 7.5 cm. Find its distance from the mirror if image formed is 0.6 cm in size.
Q-30	A candle flame 1.6 cm high is imaged in a polished ball of a bearing of diameter 0.4 cm. If the ball bearing is 20 cm away from the flame, find location and the height of the image.
Q-31	A 3 cm tall object is placed at a distance of 7.5 cm from a convex mirror of focal length 6 cm. Find the location, size and nature of the image.
Q-32	A U shaped wire is placed infront of a concave mirror having radius of curvature 20 cm as shown in the figure. Find total length of the image. 
Q-33	A man uses a concave mirror for shaving. He keeps his face at a distance of 25 cm from the mirror and gets an image 1.4 times enlarged. Find the focal length of the mirror.
Q-34	Find the diameter of an image of moon formed by a spherical concave mirror of focal length 7.6 m. The diameter of the moon is 3450 km and distance between the earth and the moon is 3.8×10^5 km.
Q-35	A particle goes in a circle of radius 2.0 cm. A concave mirror of focal length 20cm is placed with its principal axis passing through the center of the circle and perpendicular to its plane. The distance between the pole of the mirror and the center of the circle is 30 cm. Calculate the radius of the circle formed by the image.
Q-36	A concave mirror of radius R is kept on a horizontal table as shown in the figure. Water (refractive index μ) is poured into it upto height h. Where should an object be placed so that its image is formed on itself? 
Q-37	A point source S is placed midway between two converging mirrors having equal focal length f as shown in the figure. Find the value of d for which only one image is formed. 
Q-38	A converging mirror M_1, a point source S and a diverging mirror M_2 are arranged as shown in the figure. A source is placed at a distance of 30 cm from M_1. The focal length of each mirror is 20 cm. Consider only the images formed by a maximum of two reflections and the images coincide. (a) Find the distance between the two mirrors. (b) Find the location of the image formed by the single reflection from M_2. 

Q-39	A light ray falling at an angle of 45^0 with the surface of a clean slab of ice of thickness 1.00 m is refracted into it at an angle of 30^0. Calculate the time taken by light to cross the slab. Speed of light in vacuum is 3×10^8 m/s.
Q-40	A pole of length 1.00 m stands half dipped in a swimming pool with water level 50.0 cm higher than the bed. Refractive index of water is 1.33 and sunlight is coming at an angle of 45^0 with the vertical. Find the length of shadow of the pole on the bed.
Q-41	A small piece of wood is floating on the surface of a 2.5 m deep lake. Where does shadow form on the bottom when the sun light is just setting? Refractive index of water is $\frac{4}{3}$.
Q-42	An object P is focused by a microscope M. A glass slab of thickness 2.1 cm is introduced between P and M. If the refractive index of the slab is 1.5 by what distance should the microscope be shifted to focus the object again?
Q-43	A vessel contains water upto a height of 20 cm and above it an oil upto another 20 cm. Refractive index of water and oil are 1.33 and 1.30 respectively. Find the apparent depth of the vessel when viewed from above.
Q-44	Locate the image of point P as seen by the eye in the figure. 
Q-45	k number of transparent slabs are arranged one over another. The refractive indices of the slabs are $\mu_1, \mu_2, \mu_3, \ldots . \mu_k$. and their thickness are $t_1, t_2, t_3, \ldots . t_k$ respectively. An object is seen through this combination with nearly perpendicular light. Find the equivalent refractive index of the system which will allow the image to be formed at the same place.
Q-46	A cylindrical vessel of diameter 12 cm contains $800\,\pi$ cm^3 of water. A cylindrical glass piece is placed in the vessel. If the bottom of the vessel under the glass piece is seen by the paraxial rays as shown in the figure locate its image. The index of refraction of glass is 1.50 and that of water is 1.33. 
Q-47	Consider the situation shown in the figure. The bottom of the pot is a reflecting plane mirror, F is a small fish and E is a human eye. Refractive index of water is μ. (a) At what distance(s) from itself will the fish see the images(s) of the eye? (b) At what distance(s) from itself will the eye see the image(s) of the fish? 
Q-48	A small object is placed at the center of the bottom of a cylindrical vessel of radius 3 cm and height 4 cm filled completely with water. Consider the ray leaving the vessel through the corner. Suppose this ray and the ray along the axis of the vessel are used to trace the image. Find (a) the apparent depth of the image and (b) the ratio of real depth to the apparent depth under the assumptions taken. Refractive index of water is 1.33.

Q-49	A cylindrical vessel, whose diameter and height both are equal to 30 cm, is placed on a horizontal surface and a small particle P is placed in it at a distance of 5,0 cm from the center. An eye is placed at a position such that the edge of the bottom is just visible as shown in the figure. The particle P is in the plane of drawing. Upto what minimum height should water be poured in the vessel to make the particle visible? Refractive index of water $_a\mu_w = 1.33$
Q-50	A light ray is incident at an angle of 45^0 with the normal to a plate $\sqrt{2}$ cm thickness having of refractive index 2.0. Find shift in the path of the light as it emerges out from the plate.
Q-51	An optical fiber (μ = 1.72) us surrounded by a glass coating (μ = 1.50). Find the critical angle for total internal reflection at the fiber-glass interface.
Q-52	A light ray is incident on the face AB of a right-angled prism ABC (μ = 1.50) as shown in the figure. What is the largest angle ϕ for which the light ray is totally reflected at the surface AC? 
Q-53	Find the maximum angle of refraction when light ray is refracted from glass (μ = 1.50) to air.
Q-54	Light is incident from glass (μ = 1.50) to air. Sketch the variation of the angle of deviation δ with the angle of incidence i for $0 < i < 90^0$.
Q-55	Light is incident from glass (μ = 1.50) to water (μ = 1.33). Find the range of angle of deviation for which there are two angles incidence.
Q-56	Light falls from glass (μ = 1.50) to air. Find the angle of incidence for which the angle of deviation is 90^0.
Q-57	A point source is placed at a depth h below the surface of water having refractive index μ. (a) Show that light escapes through a circular area on the water surface with its centre directly above the point source. (b) Find the angle subtended by a radius of the area on the source.
Q-58	A container contains water upto height of 20 cm and there is appoint source at the centre of the bottom of the container. A rubber ring of radius r floats centrally on the water. The ceiling of the room is 2.0 m above the water surface. (a) Find the radius of the shadow of the ring formed on the ceiling if r = 15 cm.. (b) Find the maximum value of r for which the shadow of the ring is formed on the ceiling. Refractive index of water is $\frac{4}{3}$.
Q-59	Find the angle of minimum deviation for an equilateral prism made of a material of refractive index 1.732. What is the angle of incidence for this deviation?
Q-60	Find the angle of deviation suffered by the light ray shown in the figure. The refractive index $\mu = 1.5$ for the prism material. 
Q-61	A light ray, going through a prism with the angle of prism 60^0, is found to deviate by 30^0. What limit on the refractive index can be put from these data?

Q-62	Locate the image formed by refraction in the situation shown in the figure. 
Q-63	A spherical surface of radius 30 cm separates two transparent media A and B with refractive indices 1.33 and 1.48 respectively. The medium A is on the convex side of the surface. Where should a point object be placed in medium A so that the paraxial rays become parallel after refraction at the surface?
Q-64	Figure shows a transparent hemisphere of radius 3.0 cm made of a material of refractive index 2.0.  (a) A narrow beam of the parallel rays is incident on the hemisphere as shown in the figure. Are the rays totally reflected at the plane surface? (b) Find the image formed by the refraction at the first surface? (c) Find the image formed by the reflection or by the refraction at the plane surface? (d) Trace qualitatively the final rays as they come out of the hemisphere.
Q-65	A small object is embedded in a glass sphere $(\mu = 1.5)$ of radius 5.0 cm at a distance 1.5 cm left to the centre. Locate the image of the object as seen by an observer standing (a) to the left of the sphere and (b) to the right of the sphere
Q-66	A biconvex thick lens is constructed with glass $\mu = 1.50$. Each of the surfaces has a radius of 10 cm and the thickness at the middle is 5 cm. Locate the image of an object placed far away from the lens.
Q-67	A narrow pencil of parallel light is incident normally on a solid transparent sphere of radius *r*. What should be the refractive index if pencil is to be focused (a) at the surface of the sphere, (b) at the centre of the sphere.
Q-68	One end of a cylindrical glass rod $(\mu = 1.50)$ of radius 1.0 cm is rounded in the shape of a hemisphere. The rod is immersed in water $\left(\mu = \frac{4}{3}\right)$ and an object is placed in the water along the axis of the rod at a distance of 8.0 cm from the rounded edge. Locate the image of the object.
Q-69	A paperweight in the form of a hemisphere of radius 3.0 cm is used to hold down a printed page. An observer looks at the page vertically through the paperweight. At what height above the page will the printed letters near the centre appear to the observer?
Q-70	If paperweight in the form of a hemisphere of radius 3.0 cm is used to hold down a printed page is inverted so that the spherical surface touches the paper. An observer looks at the page vertically through the paperweight. At what height above the page will the printed letters near the centre appear to the observer?
Q-71	A hemispherical portion of the surface of a solid glass sphere $(\mu = 1.5)$ of radius *r* is silvered to make inner side reflecting. An object is placed on the axis of the hemisphere at a distance 3*r* from the centre of the sphere. The light from the object is refracted at the unsilvered part and then reflected from the silvered part and again refracted from unsilvered part. Locate the final image formed.

Q-72	A convex surface of a thin concavo-convex lens of the glass of refractive index 1.5 has a radius of curvature 20 cm. The concave surface has a radius of curvature 60 cm. The convex side is silvered and placed on a horizontal surface as shown in the figure. (a) Where should a pin be placed on the axis so that its image is formed at the same place? (b) If the concave part is filled with water $\left(\mu = \frac{4}{3}\right)$, find the distance through which the pin should be moved so that the image of the pin again coincides with the pin.
Q-73	A double convex lens has focal length 25 cm. The radius of curvature of one of the surface is double of the other. Find the radii, if the refractive index of the material of the lens is 1.5.
Q-74	The radii of curvature of a lens are +20 and +30 cm. The material of the lens has a refractive index 1.6. Find the focal length of the lens (a) If it is placed in air and (b) If it is placed in water $(\mu = 1.33)$
Q-75	Lenses are constructed by a material of refractive index 1.50. The magnitude of the radii of curvature are 20 cm and 30 cm. Find the focal length of the possible lenses with the above specification. .
Q-76	A thin lens made of a material of refractive index μ_2 has a medium of refractive index μ_1 on one side and a medium of refractive index μ_3 on the other side. . The lens is biconvex and the the two radii of curvature have equal magnitude *R*. A beam of light travelling parallel to the principal axis is incident on the lens. Where will the image be formed if the beam is incident - (a) From the medium μ_1 and (b) From the medium μ_3
Q-77	A convex lens has a focal length of 10 cm. Find the location and nature of the image if a point object is placed on the principal axis at a distance of (a) 9.8 cm, (b) 10.2 cm from the lens.
Q-78	A slide projector has to project a 35 mm slide $(35\text{mm} \times 23\text{mm})$ on a $(2\text{ m} \times 2\text{ m})$ screen at a distance of 10 m from lens. What should be focal length of the lens in projector.
Q-79	A particle executes a simple harmonic motion of amplitude 1.0 cm along the principal axis of a convex lens of focal length 12 cm. The mean position of the oscillation is at 20 cm from the lens. Find the amplitude of oscillation of the image of the particle.
Q-80	An extended object is placed at a distance of 5.0 cm from a convex lens of focal length 8.0 cm (a) Draw the ray diagram (to the scale) to locate the image from the lens. (b) Find the position of image from the lens formula and see how close the drawing us to the correct result.
Q-81	A pin of length 2.00 cm is placed perpendicular to the principal axis of a converging lens. An inverted image of size 1.00 cm is formed at a distance 40.0 cm from the pin. Find focal length of the lens and its distance from the pin.
Q-82	Is the formula "Real Depth/Apparent Depth = μ" valid if viewed from a position quite away from the normal?
Q-83	Can you ever have a situation in which light ray goes undeviated through a prism?
Q-84	Why does a diamond shine more than a glass cut to the same shape?

Q-85	A narrow beam of light passes through a slab obliquely and is then received by an eye as shown in the figure. The index of refraction of the material in the slab fluctuates slowly with time. How will it appear to the eye? The twinkling of star has similar explanation. 
Q-87	If a piece of paper is placed at the position of a virtual image of a strong light source, will the paper burn after sufficient time? What happen if the image is real? What happen if image is real but source is virtual?
Q-88	Can a virtual image be photographed by a camera?
Q-89	In motor vehicles, a convex mirror is attached near the driver's seat to give him the view of the traffic behind. What is the special function of this convex mirror which a plane mirror cannot do?
Q-90	If an object far away from the convex mirror moves towards the mirror, the image also moves. Does it move faster, slower or at the same speed as compared to the object?
Q-91	Suppose you are inside the water in a swimming pool near an edge. A friend is standing on the edge. Do you find your friend taller or shorter than his usual height?
Q-92	The equation of refraction at a spherical surface is $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$. Taking $R = \infty$ show that equation leads to $\frac{\text{Real Depth}}{\text{Apparent Depth}} = \frac{\mu_1}{\mu_2}$ for refraction at a plane.
Q-93	A thin converging lens is formed with one surface convex and the other plane. Does the position of image depend whether the convex surface or the plane surface faces the object?
Q-94	A single lens is mounted in a tube. A parallel beam enters tube and emerges out of the tube as a divergent beam. Can you say with certainty that there is a divergent lens in the tube?
Q-95	An air bubble is formed inside water. Does it act as a converging lens or diverging lens?
Q-96	Two converging lenses of unequal focal lengths can be used to reduce the aperture of a parallel beam of light without losing the energy of the light. This increases the intensity. Describe how the converging lenses should be placed to do this.
Q-97	If a spherical mirror is dipped in water, does its focal length change?
Q-98	If a thin lens is dipped in water, does its focal length change?
Q-99	Can mirror give rise to chromatic aberration?
Q-100	A laser light is focused by a converging lens. Will there be a significant chromatic aberration?

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