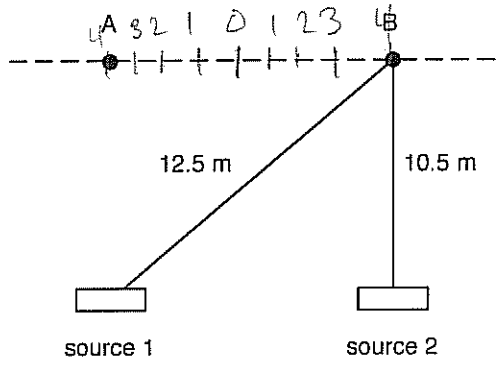
Physics 1520, Fall 2013
Quiz 2, Form: A

Name: Key
Date: _____

Section 1. Exercises

1. Two identical point sources of radio waves are at locations 1 and 2. Each source emits radio waves of wavelength 0.5 m. The location B is 12.5 m from source 1 and 10.5 m from source 2. What type of interference will occur at location B?



$\lambda = 0.5\,m$

path diff $= 12.5\,m - 10.5\,m$

$= 2\,m = m\lambda$

$m = \frac{2\,m}{0.5\,m} = 4$

(a) total constructive
(b) total destructive
(c) Neither of the above because the conditions aren't exactly right to produce total constructive or total destructive interference.

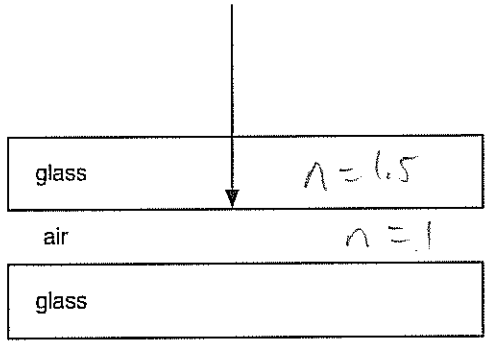
2. How many locations *between* points A and B will have total constructive interference? (Do not count A and B if total constructive interference occurs at those locations.)

(a) 0
(b) 1
(c) 2
(d) 3
(e) 4

Since $m = 4$, then there is also a location for total constructive interference at $m = 0, 1, 2, 3$ and $m = 1, 2, 3$ on other side closer to A.

Answer is 7

Questions 3–4: Two glass microscope slides of index $n = 1.5$ are pressed together. Air is trapped between the glass slides as shown below.



3. Light reflecting from the glass-air boundary at the location shown above will

(a) have no phase change compared to the incident wave at that boundary.
(b) undergo a phase change of 180° compared to the incident wave at that boundary.

4. Light reflecting from the glass-air boundary interferes with light traveling through the layer of air and reflecting off the bottom of the layer of air at the air-glass boundary. If the thickness of the layer of air is 125 nm, what visible wavelength will result in total constructive interference? (Note that visible wavelengths are approximately between 400 nm and 700 nm.)

(a) 625 nm
(b) 438 nm
(c) 563 nm
(d) 688 nm
(e) 500 nm

$t = 125\,nm$ 1 phase change (at bottom of the layer of air)
$n = 1$ $2t = (m + \frac{1}{2})\frac{\lambda}{n}$
$m = 0$ $\lambda = 4t = 4(125\,nm) = 500\,nm$

5. You shine a green laser onto glass. What quantities change as the light passes from the air into the glass?

(a) speed only
(b) frequency only
(c) wavelength only
(d) speed and frequency
(e) speed and wavelength

f stays the same.

6. A thin film of index 1.25 is on a glass window of index 1.5. The thin film is designed to reflect infrared light of wavelength 1000 nm. Which wavelength below is closest to the wavelength of the infrared radiation while it is in the thin film?

(a) 1500 nm
(b) 1250 nm
(c) 1000 nm
(d) 800 nm
(e) 670 nm

$\lambda_{medium} = \frac{\lambda_{vacuum}}{n} = \frac{1000\,nm}{1.25}$
$= 800\,nm$

7. Red light of wavelength 630 nm passes through two slits and then onto a screen 1.2 m from the slits. The center of the 3rd order bright band (i.e. fringe) on the screen is separated from the central maximum by 0.8 cm. What is the distance between the slits?

(a) 0.19 mm
(b) 0.095 mm
(c) 0.28 mm
(d) 0.019 mm
(e) 0.8 mm

$y_m = \frac{m\lambda L}{d}$
$m = 3$
$\lambda = 630 \times 10^{-9}\,m$
$d = ?$
$d = \frac{3(630 \times 10^{-9}\,m)(1.2\,m)}{0.8 \times 10^{-2}\,m}$
$= 2.84 \times 10^{-4}\,m = 0.284\,mm$

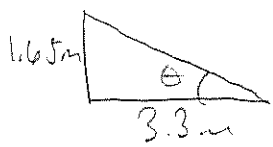
8. If you repeat the previous experiment with blue light of 450 nm, the distance from the central maximum to the 3rd order bright fringe will be

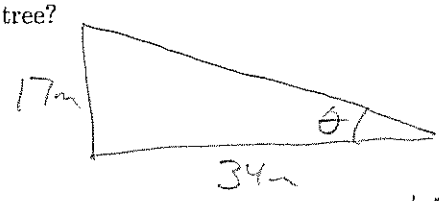
(a) greater than 0.8 cm
(b) less than 0.8 cm
(c) 0.8 cm

$y_m \propto \lambda$
so shorter λ results in fringes closer together.

9. You are 1.65 m tall, and you stand next to a tree. The tree's shadow on the level ground is 34 m long, and your shadow is twice your height. How tall is the tree?

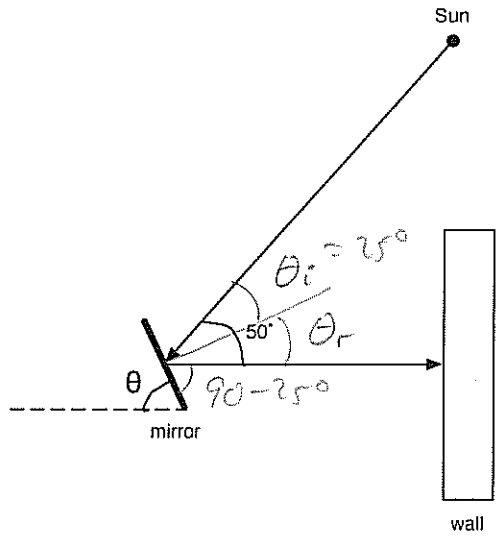
(a) 34 m
(b) 68 m
(c) 21 m
(d) 17 m
(e) 10 m





Similar triangles. $\tan\theta = \frac{1.65\text{m}}{3.3\text{m}} = 0.5$

Questions 10–11: You hold a small mirror ~~south~~ such that sunlight reflects from the mirror and makes a spot on the wall that is at the same height as the mirror. One ray from the Sun that reflects from the mirror is shown below.



10. If the Sun is 50° above the horizontal, what is the angle θ for the tilt of the mirror with respect to the horizontal?

(a) 25°
(b) 50°
(c) 65°
(d) 40°
(e) 75°

$\theta_i = \theta_r = 25°$

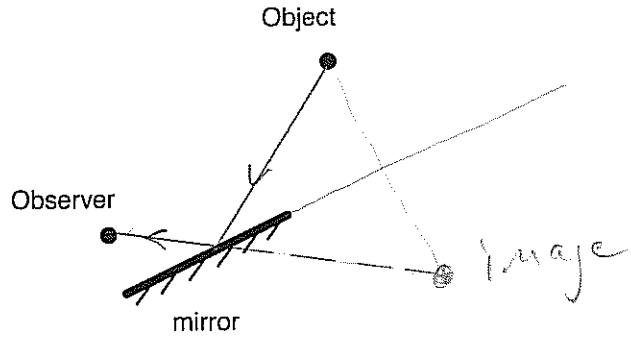
$\theta = 90 - 25° = \boxed{65°}$

11. The Sun is a distant source. If I sketch other rays coming from the Sun and reflecting from the mirror, I should draw the rays

(a) parallel to the ray shown.
(b) diverging with respect to the ray shown.
(c) converging with respect to the ray shown.

Light rays from a distant source are parallel.

12. An observer and object are on the same side of a plane mirror as shown below. Will the observer see the object?



(a) yes — A ray appears to come from the image behind the mirror
(b) no
(c) It can't be determined without being given the distance of the object from the mirror.

13. A beam of light passes from air into a transparent petroleum product called cyclohexane at an angle of 48° with respect to the normal. The angle of refraction is 31°. What is n for cyclohexane?

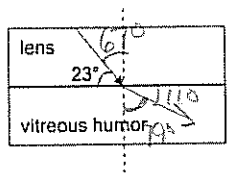
(a) 0.694
(b) 1.55
(c) 1.15
(d) 1.28
(e) 1.44

$\theta_1 = 48°$ $\quad n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\theta_2 = 31°$ $\quad 1 \sin(48°) = n_2 \sin(31°)$

$\boxed{n_2 = 1.44}$

14. Behind the lens of the eye is the vitreous humor, a jellylike substance that occupies most of the eyeball. The refractive index of the vitreous humor is 1.35 and that of the lens is 1.44. A beam of light traveling in the lens comes to the interface at a 23° *with respect to the surface of the lens.*



$n_1 = 1.44$ $\quad \theta_1 = 90° - 23° = 67°$

$n_2 = 1.35$

What is the direction of the beam *with respect to the surface,* when in the vitreous humor?

(a) 79°
(b) 60°
(c) 11°
(d) 30°
(e) 25°

it bends away from the normal

$n_1 \sin(\theta_1) = n_2 \sin\theta_2$

$\theta_2 = \sin^{-1}\left(\frac{1.44 \sin(67°)}{1.35}\right) = 79°$

So with respect to the surface, $\boxed{\theta = 11°}$

15. You swim under water at night and shine a laser so that it hits the water-air interface at an incident angle of 52° with respect to the normal. Will your friend see the light above the water? The index of refraction of water is 1.33.

(a) Yes, but only if the stand at the angle that the light refracts from the water-air interface?
(b) Yes, but only if they lay their head near the surface of the water and look along the surface of the water.
(c) Yes, they will see it at any angle that they look at the water.
(d) No.

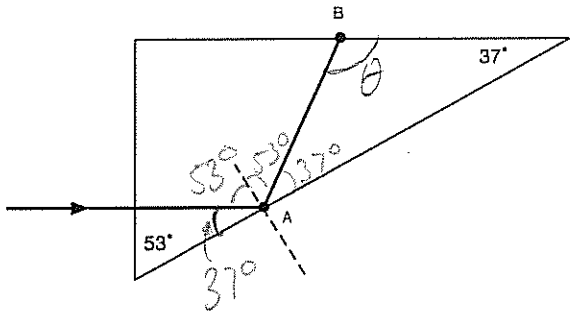
Find critical angle.

$n_1 \sin(\theta_c) = n_2$

$\theta_c = \sin^{-1}\left(\frac{1}{1.33}\right) = \boxed{49°}$

$\theta_1 > \theta_c$ so total internal reflection occurs.

Questions 16–18: A ray of light strikes one side of a prism (made of some material) perpendicular to the surface as shown below.



16. What must be the minimum value of the index of refraction of the prism in order that light is total internally reflected at location A?

(a) 1.66
(b) 1.25
(c) 3.63
(d) 1.50
(e) 1.33

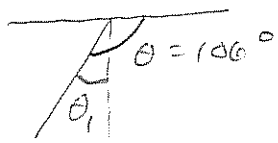
$\sin\theta_c = \frac{n_2}{n_1}$ n_1 = prism, n_2 = air.

$n_1 = \frac{1}{\sin\theta_c} = \frac{1}{\sin(53°)} = \boxed{1.25}$

17. With what angle (with respect to the normal) does the ray hit the surface of the prism at location B?

(a) 37°
(b) 74°
(c) 53°
(d) 24°
(e) 16°

$\theta = 180 - 37 - 37 = 106°$



$\theta_1 = 106° - 90° = 16°$

18. Will light emerge from the top surface at B?

(a) no
(b) yes
(c) There's not enough information to answer this question definitively.

yes because $\theta_1 < \theta_c$

Questions 19–21: Suppose that for your eye, it is 2.15 cm from the lens of the eye to the retina. (We're treating the cornea and lens together as a single lens.) A book held at 30 cm from the eye produces an image that is 2.26 cm from the lens. (Thus the image distance is "behind" the retina.)

19. What is the focal length of the eye in this case?

(a) 2.01 cm
(b) 2.26 cm
(c) 2.10 cm
(d) 2.44 cm
(e) 2.15 cm

$s = 30$ cm
$s' = 2.26$ cm

$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'} = \frac{1}{30} + \frac{1}{2.26}$

$\boxed{f = 2.10 \text{ cm}}$

20. Are you farsighted or nearsighted?

(a) farsighted
(b) nearsighted

You can't create an image of a nearby object at the retina.

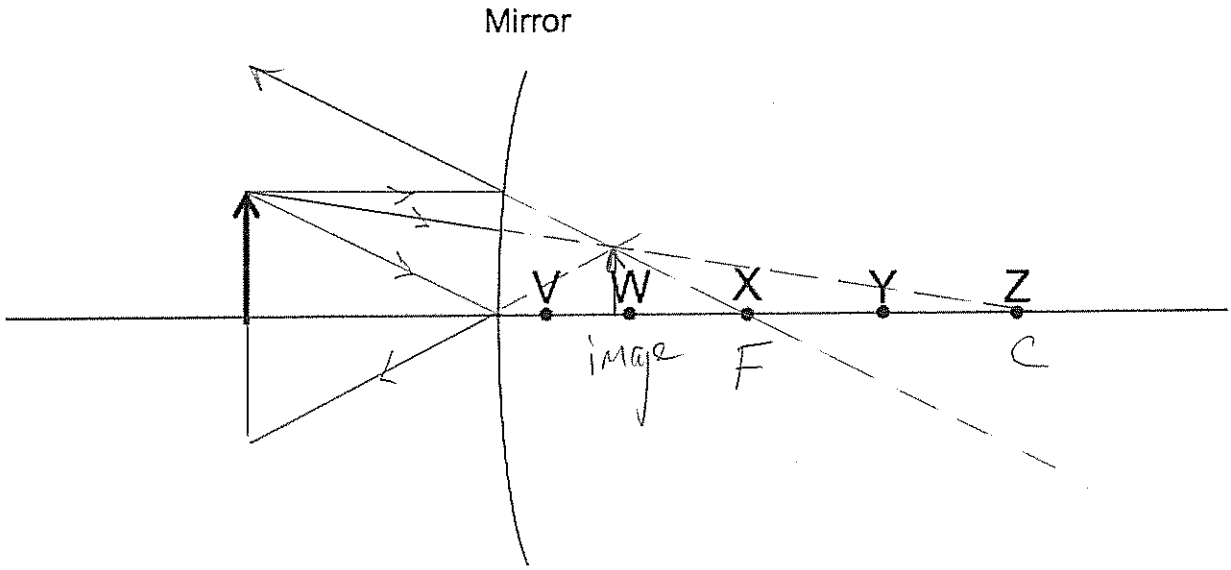
21. Through surgery, the focal length can be adjusted. What should be the focal length of the eye in order to read the book held at 30 cm with no need for glasses?

(a) 2.32 cm
(b) 2.44 cm
(c) 2.15 cm
(d) 2.10 cm
(e) 2.01 cm

$s' = 2.15\text{ cm}$
$f = ?$
$s = 30\text{ cm}$

$\frac{1}{f} = \frac{1}{s'} + \frac{1}{s}$
$= \frac{1}{2.15\text{cm}} + \frac{1}{30\text{cm}}$
$f = 2.01\text{ cm}$

22. An object is in front of a convex mirror as shown below. Point Z is the center of the mirror.



Which point is closest to where the image will be located?

(a) V
(b) W
(c) X
(d) Y
(e) Z

23. You need a mirror for shaving or makeup. The mirror should produce an image that is upright and magnified by a factor of 2.0 when held 15 cm from your face. What type and focal length mirror should you order?

(a) convex mirror; $f = 30$ cm
(b) convex mirror; $f = 10$ cm
(c) convex mirror; $f = -30$ cm
(d) concave mirror; $f = 30$ cm
(e) concave mirror; $f = 10$ cm

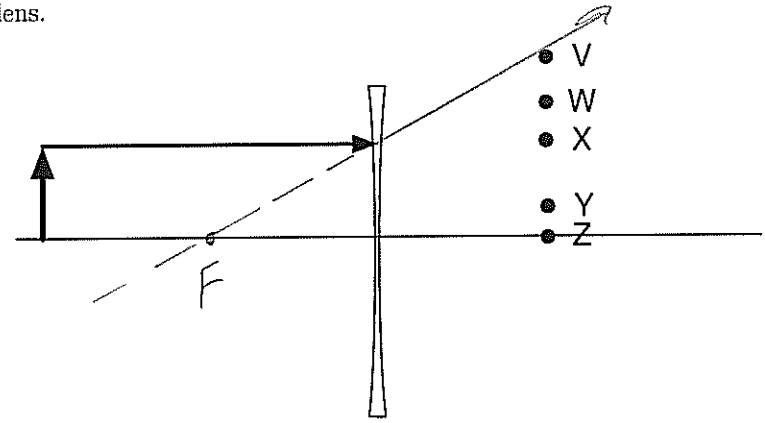
$s = 15\text{ cm}$
$m = 2$

So $s' = -ms$
$= -2(15\text{cm})$
$= -30\text{cm}$
↑ virtual image.

$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$
$= \frac{1}{15\text{cm}} + \frac{1}{-30\text{cm}}$
$f = +30\text{cm}$

Converging mirror, thus concave

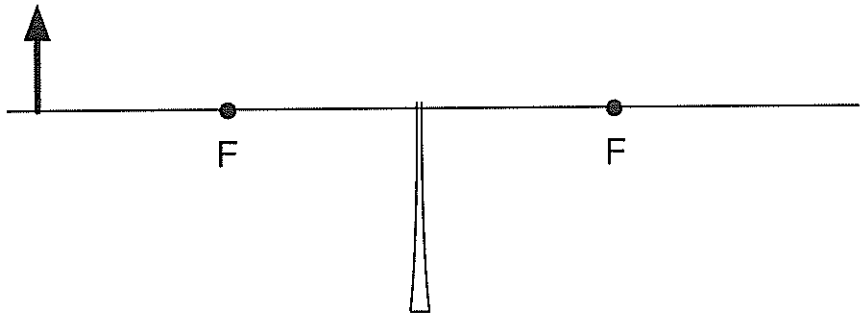
24. A diverging lens is used to create an image of an object. Point Z is at one of the focal points of the lens.



A single ray from the top of the object is drawn in the orientation shown. Through which point will this ray travel?

(a) V
(b) W
(c) X
(d) Y
(e) Z

25. Suppose that you only have half a lens as shown below.



Compared to the image formed by a whole lens, this image will be

(a) half an image, with the top half of the object missing.
(b) half an image, with the bottom half of the object missing.
(c) the entire image at the same location as before, but dimmer.
(d) nonexistent. There will be no image.
(e) the same image, but inverted.