1. A photographer's use of a filter to darken the sky and make the clouds appear whiter in contrast makes use of the property of____________ because dust particles in the atmosphere scatter (reflection) more blue light than other colours.

   A. dispersion   ✓B. polarization
   C. refraction   D. interference

   polarization

2. A shopper looking into a store window sees reflections from the street which prevent her from seeing clearly into the store. Being a serious physics student, she thinks about reflection and polarization and remembers that she has polarized sunglasses in her purse. She wonders whether or not she could remove those reflections by using her sunglasses. She decides to ask herself some questions and then experiment to see if the glasses would help. Answer her questions, (a well labelled diagram might help), and decide what she should do.

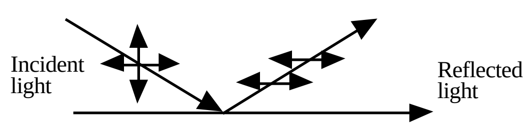
   a) How is light polarized when it reflects from any surface? (Make a diagram to explain) (1 mark)

   b) How do sunglasses reduce the glare from reflected light? (1 mark)

   c) How could she use the glasses to reduce the window glare? (1 mark)

   Suggested Response

   a) Unpolarized light hits the surface, and some of the components perpendicular to the surface are absorbed, leaving the parallel components to be reflected back. Light leaving is polarized parallel to the plane of the reflecting surface.



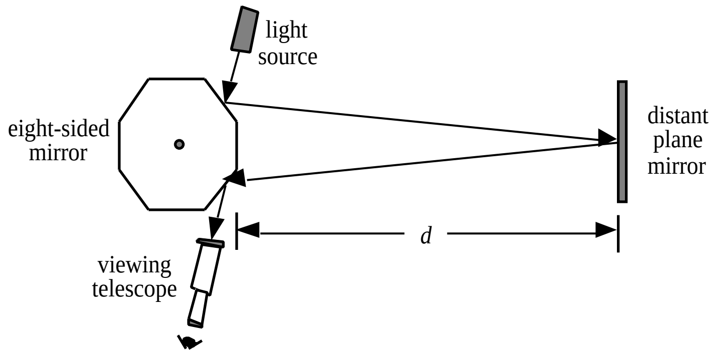
   b) Polarized sunglasses are oriented so that they let in vertically polarized components of light and absorb horizontally polarized components. Most reflecting surfaces such as water, pavement, etc., are in the horizontal plane, so they are removed by the polarized sunglasses.

   c) Window is vertical, so light leaving it will be polarized vertically.

   d) If she rotated her lenses 90^{o}, she could remove the vertically polarized light and see in the window.

Use this information to answer the following next 1 question(s).

The diagram represents a reproduction of Michelson's light experiment.



3. In reference to the diagram, the distance between the eight-sided mirror and the plane mirror is 35.0 km and the frequency of rotation of the eight-sided mirror is 480 Hz. Calculate the speed of light.
4 marks
Answer:

Time for one rotation of mirror

$T = \frac{1}{f}$

$= \frac{1}{480\text{Hz}}$

$= 0.00208 \text{ s}$ (1 mark)

Time for $\frac{1}{8}$ rotation of mirror

$\frac{T}{8} = \frac{0.00208\text{s}}{8}$

$= 2.60 \times 10^{-4} \text{ s}$ (1 mark)

Speed of light

$d = 2 \times 35.0 \text{ km}$

$= 70.0 \text{ km} \times \frac{1000\text{m}}{1 \text{ km}}$

$= 7.00 \times 10^{4} \text{ m}$ (1 mark)

$v = \frac{d}{t}$

$= \frac{7.00 \times 10^{4} \text{ m}}{2.60 \times 10^{-4} \text{ s}}$

$= 2.69 \times 10^{8} \text{ m/s}$ (1mark)

4. In an experiment similar to Michelson's, a rotating mirror with 30 faces rotates at the correct speed for the "first image" to appear. If the distance from the rotating mirror to the fixed mirror is 4.50 km, what is its frequency of rotation if the experiment found the speed of light to be 3.00×10^{8}m/s?

A. 2.22 kHz
✓B. 1.11 kHz
C. 4.44 kHz
D. .556 kHz

v =Δd /Δt
v= 2 x pipe distance /
(1 / f x 1/ # of sides of mirror)
v= 2 x 4.5 km / (1 / f) x (1/ 30)

5. Roemer calculated that it would take light 22 min to travel the diameter of earth's orbit. Using this value for the time of travel and 3.0 x 10^{11} m as the value for the diameter of earth's orbit, calculate the speed of light.
4 marks
Answer:

$$v = \frac{d}{t}$$
$$= \frac{3.0 \times 10^{11}\text{ m}}{(22\text{min})\left(\frac{60\text{s}}{1\text{min}}\right)}$$
$$= 2.3 \times 10^{8}\text{ m/s}$$

6. Students recorded the speed of light in four substances in this table.

Substance	Speed ($\times 10^8$ m/s)
W	2.04
X	1.56
Y	1.23
Z	1.97

From lowest to highest, the order of critical angles of these substances is

A. Z, Y, X, and W
✓B. Y, X, Z, and W
C. W, Z, X, and Y
D. W, X, Y, and Z

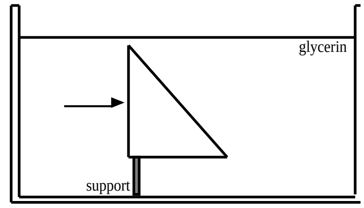
n=c/v
sin $ø_c$ = n2/ n1
the slower the speed the greater the index of refraction. The greater the index of refraction the smaller the critical angle.

7. What is the critical angle when light is going from water into air?

(n for water is 1.33)

A) sin $ø_c$ = n2/ n1 = 48.6°

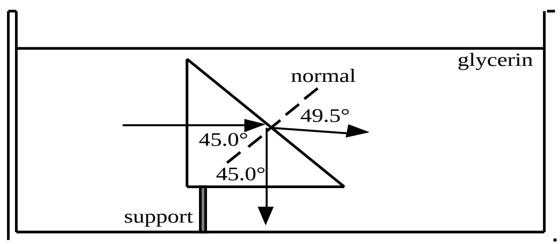
8. The diagram shows a ray of light striking a right triangular prism that is supported and immersed in glycerin.
The index of refraction of the glass is 1.58 and glycerin 1.47.



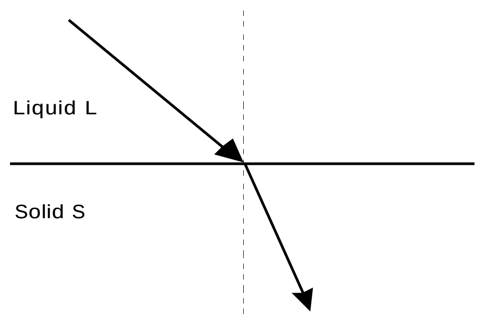
Calculate where and at what angle will the light ray leave the prism? (the prisim has 45º angles)
3 marks

It passes straight into the prism because it strikes at 90º. Then it strikes at an angle of 45º which must be less than the critical angle as the two material are nearly the same index of refraction.
To find the angle it leaves the prism we use snell's law n1 sinø1 = n2 sinø2 = 49.5º

A sample answer follows.



9. A student performing an optics experiment and drew a scale diagram of the experimental results. The light from a halogen source is travelling through liquid L and solid S.

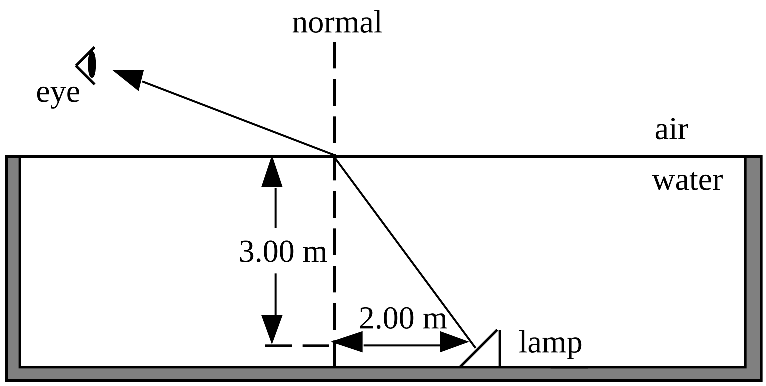


Which of the following would be a logical conclusion from this empirical result?

A. the particle model of light explains this result better than the wave model
✓B. the critical angle for light travelling from S into air is less than for light travelling from L into air
C. the wavelength of the halogen light in S is greater than in L
D. the frequency of the halogen light in S is less than in L

B

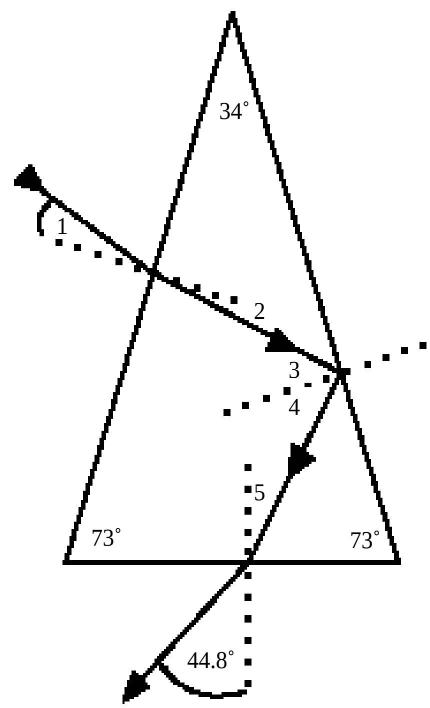
10. The diagram shows a light ray travelling into the air from a lamp 3.00 m below the surface of a pool of water. The lamp is located 2.00 m from a point directly below where the light leaves the water on its way to the eye. The index of refraction of water is 1.33.



Relative to the surface of the water, at what angle does the light leave the water?
4 marks
tan ø1 = 2 m / 3 m
ø1 = 33.7 º
n1 sinø1 = n2 sinø2
ø 2 = 42.5°

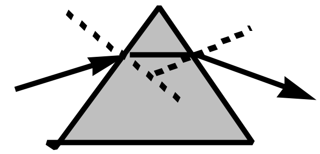
11.

A ray of light entered and exited a glass prism (n = 1.50), as shown.
The angle of incidence marked "1" is



✓A. 16.6˚
B. 13.7˚
C. 16.5˚
D. 9.0˚
16.6˚

12. A beam of light enters an equilateral prism 60º angles as shown. Calculate the angle of refraction at Ø2 if the beam enters at Ø1 with an angle of 40º if the prism has an index of refraction of 1.5.



[4 marks]

n sin ø = n sin ø
1 sin 40 / 1.5 = 25.4 º
90 - 25.4 = 64.6
180-60-64.6 = 55.4
90 - 55.4 = 34.6
n sin ø = n sin ø
1.5 sin 34.6 = 1 sin ø
ø2 = 58.4º

13. **Written Response**

A ray of light travelling from air into ethanol is refracted at an angle of 37°. If the speed of light in ethanol is 2.19×10^8 m/s,

A) Draw and label a diagram to represent the above statement. **1 mark**

B) Determine the index of refraction for the ethanol. **2 marks**

C) Determine the angle of incidence. **2 marks**

For the diagram the angle incidence and refraction and normal

n2 / n1 = v1 / v2
n2 = 1.37

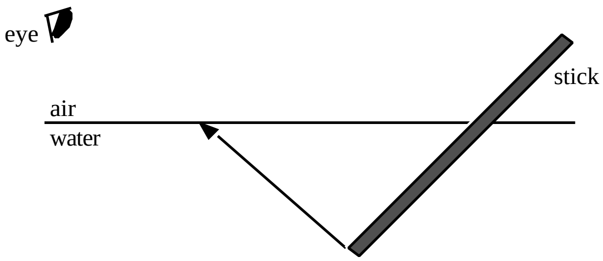
v1 / v2 = sinø1 / sinø2
ø1 = 55.5º

14. When white light travels through a triangular glass prism, into what order of colours does it separate from least to most refracted?

✓A. Red, orange, yellow, green, blue, indigo, and violet
B. Violet, indigo, blue, green, yellow, orange, and red
C. Violet, indigo, green, blue, yellow, orange, and red
D. Red, orange, yellow, blue, green, indigo, and violet

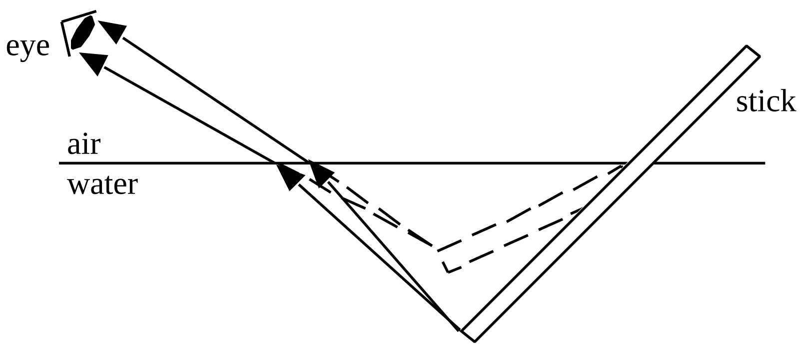
A

15. The diagram shows rays of light on their way to the eye travelling from the end of a stick partially submerged in water to the boundary with air.

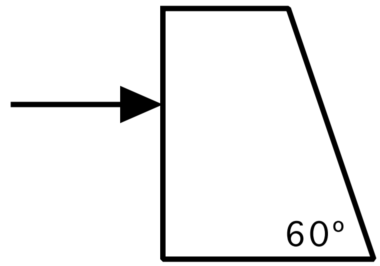


On the diagram, show how the eye sees the submerged part of the stick by drawing rays and the image of the stick in the water.
2 marks

Answer:

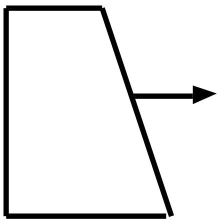


16. Light in air is incident on a glass quadrilateral (n = 1.5) as shown to the right.

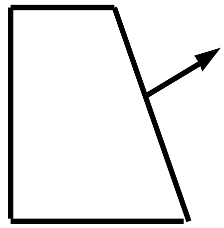


The emergent ray on the far side of the quadrilateral is

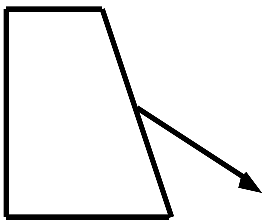
A.



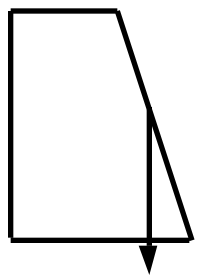
B.



✓C.



D.



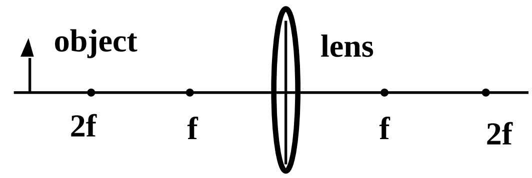
C

17. Microwaves (which travel at the speed of light) with a wavelength of 1.00 x 10^{-2} m take 6.10 x 10^{-11} s longer to travel through 3.00 x 10^{-2} m of glass than to travel the same distance through air. The index of refraction of the glass is
A. 1.41
✓B. 1.61
C. 1.64
D. 0.63

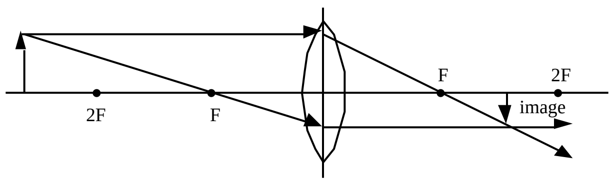
18. A microwave is incident on a prism of transparent plastic that has an index of refraction of 1.42. When the microwave passes through the prism, its speed is b x 10^8 m/s. The value of b is __________. (Round and record your answer to three digits.)

19. An object is 16.7 cm from a convex lens of focal length 12.3 cm. What is the position of the image?
A. +4.40 cm
✓B. +46.7 cm
C. +7.08 cm
D. +29.0 cm
1/f = 1/di + 1/do

20. The diagram shows an object on the left-hand side of a converging lens.



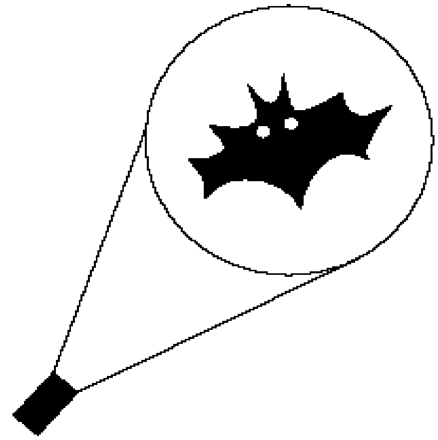
On your answer sheet draw the diagram, then the draw rays to locate the image of the object.
3 marks
Answer:
Award 2 marks for showing two paths of light to the image. Award 1 mark for locating the image.



21. Students collected data about the **real** images of objects viewed with a convex lens. What should they find about the relationship between the distance and height of an object and its image distance and height ?
   A. As the object distance decreases, the image distance decreases and the height of the image decreases.
   ✓B. As the object distance decreases, the image distance increases and the height of the image increases.
   C. As the object distance increases, the image distance decreases and the height of the image increases.
   D. As the object distance increases, the image distance increases and the height of the image decreases.
   B

22. Two convex lenses are place 10 cm apart. A 2.0 cm high object is place 3.0 cm in front of the first lens which has a 2.0 cm focus and the second lens has a focus of 3 cm, what is the final size of the image in cm?
5 marks
1/f - 1/do =1/di > di = 6 cm
m= -di/do = -2
new do = 10 - 6 = 4 cm
second di = 12 cm
m2 = -di/do = -3
mt = 6
hi = ho x m = 12 cm

23. The police department at Gotham City has set up a searchlight to project an image to let Batman know his services are needed. The batman slide is 5.0 cm across and is placed behind a convex lens so as to project a real image onto some clouds. The size of the projected image is to be 100.0 m across, and the average cloud base in Gotham city has an altitude of 500.0 m.What is the focal length of the lens used?



The focal length of the lens to be used is

A. 0.83 cm
✓B. 25 cm
C. 5.0 cm
D. 1.0 cm

m=-di /do = hi /ho note we must assume that the image is upside down or -hi
-500 m / do = -100 m / 0.05 m do = 0.25 m
1 / f = 1/di + 1/do
f= 0.25 m almost on the focus because objects projected long distances must be placed almost on the focus

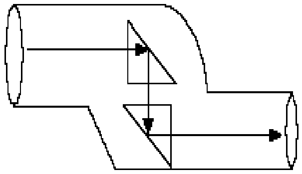
24. A) A slide projector is placed 4 m from a screen *(lens to screen)*. How far behind the lens of the projector are the slides placed if the 30 mm high by 40 mm wide slides are enlarged to 1.5 m high by 2.0 m wide when projected on the screen 4 m away?

B) What is the focal length of the lens?

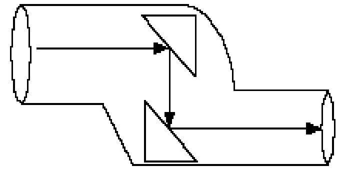
C) Is the image inverted or erect?
(5 Marks)
A) di / do = hi /ho
80 mm
B) 1/f = 1/di + 1/do
78.4 mm
C) Inverted because all images formed when they are placed beyond the focus are inverted.

25. A monocular device is designed so that the longest optical path is contained in the shortest geometrical distance without degrading the image quality. The arrangement that best meets this criteria is

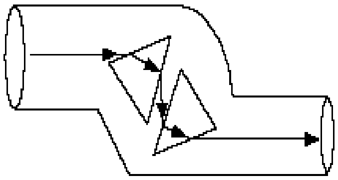
A.



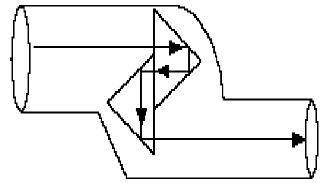
B.



C.



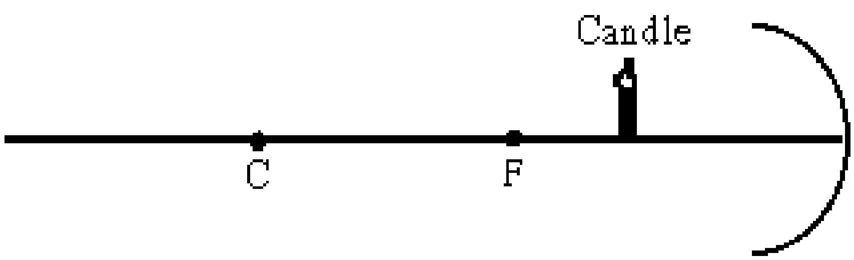
✓D.



D

26. An object 4 cm tall is placed 3 cm in front of a mirror. If the real image produced is 1.5 cm tall.
A) What is the focal length of the mirror?
4 marks
B) What type of mirror is being used?
1 mark
A) hi /ho = -di/do solve for di = 1.125
since the object is real and all real objects are inverted the distance is positive.
1/f = 1/di +1/do
0.818 cm
B) concave

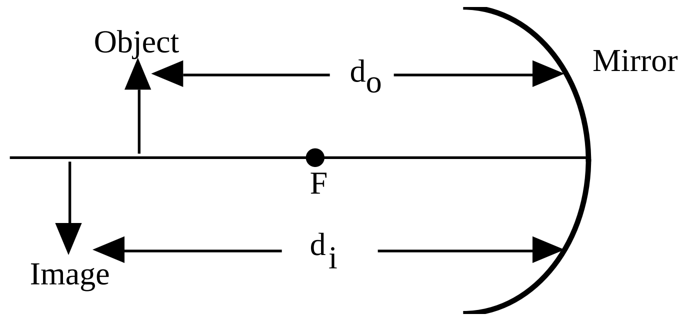
27. .What type of image is made? (three qualities)
3 marks



B) If the object was placed to be at 3 cm and the centre of curvature is 20 cm how far is the candle's image from the mirror?
3 marks

28. A student did an experiment with a concave mirror, and measured corresponding object and image distances

object distance (cm) d_o	image distance (cm) d_i
25	100
30	60
35	47
40	40
45	36



a) Make a new data table to show values of $\frac{1}{d_i}$ and $\frac{1}{d_o}$. (1 mark)

b) Plot a graph of $\frac{1}{d_o}$ verses $\frac{1}{d_i}$ treating $\frac{1}{d_o}$ as the manipulated variable. (2 marks)

c) From the graph, find an equation relating $\frac{1}{d_i}$ and $\frac{1}{d_o}$. (3 marks)

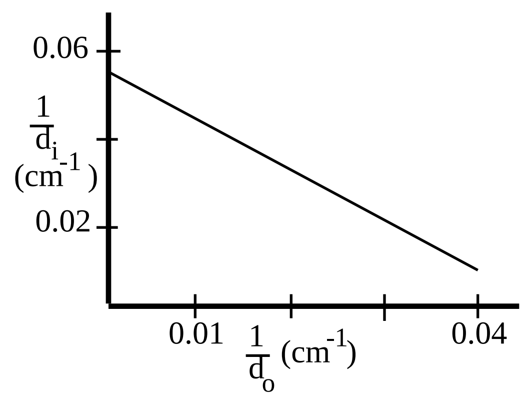
d) Using the mirror equation ($\frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{f}$) and your equation, find the focal length of the mirror. (2 marks)

Suggested Response

a)

$\frac{1}{d_o}$ (cm^{-1})	$\frac{1}{d_i}$ (cm^{-1})
0.040	0.010
0.033	0.016
0.029	0.021
0.025	0.025
0.022	0.028

b)



c) **slope =** $\frac{0.025 - 0.010}{0.025 - 0.040}$

= -1

intercept = 0.05 cm^{-1}

equation y = mx+b

$$\frac{1}{d_i} = \frac{-1}{d_o} + 0.05cm^{-1}$$

d) $\frac{1}{d_i} + \frac{1}{d_o} = 0.05$

\ $\frac{1}{f}$ **= 0.05**

and f = 20 cm

29. Relative to an object located just beyond the centre of curvature of a concave mirror, what are some of the characteristics of the image?

A. Smaller and erect
B. Larger and erect
✓C. Smaller and inverted
D. Larger and inverted

C

30. In a diffraction experiment, students project light with a wavelength of 7.20×10^{-7} m through a grating that has 450 lines/mm. At what angles will the first, second, and third-order antinodes appear respectively on each side of the central antinode?

✓A. 18.9° 40.4°, 76.4°
B. 18.6° 40.1°, 76.1°
C. 18.7° 40.2°, 76.2°
D. 18.8° 40.3°, 76.3°

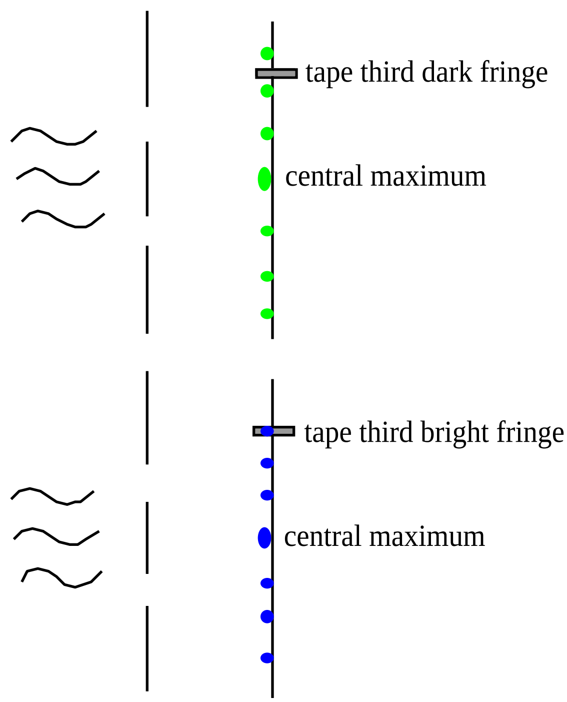
λ

31. Monochromatic light is shone through a pair of slits which are 0.100 mm apart; an interference pattern is observed on a screen 4.00 m away. The distance from the central bright spot (maxima) to the third bright spot (maxima) region is 5.00 cm. The wavelength of the light is

✓A. 4.17×10^{-7} m
B. 5.00×10^{-7} m
C. 6.25×10^{-7} m
D. 3.13×10^{-7} m

λ = xd / nl For n use 3

32. 500 nm light is incident on a pair of slits, producing an interference pattern on a distant screen. The position of the third dark fringe is marked on the screen by placing a piece of tape at its location. The 500 nm source is replaced by a new source of unknown wavelength. This new source produces its third bright fringe exactly on the piece of tape. What is the wavelength of the new source? _______________nm
(Round your answer to three significant digits)



λ = xd / nl what change between the two is n from n1 of 2.5 to n2 of 3 and the source therefore we can say
λ1 / n1 = xd / l = λ2 / n2
λ2 = 417 nm

33. Statements about Electromagnetic Waves

I. The electromagnetic spectrum covers a wide range of frequencies.
II. Different electromagnetic waves travel at different speeds in a vacuum.
III. The electromagnetic spectrum includes sound waves.
IV. All electromagnetic waves are transverse.

The true statements are
✓A. I and IV
B. I and II
C. III and IV
D. II and IV

34. This paragraph contains a factual **error**:

Electromagnetic radiation of all wavelengths travels at a speed of 3.00 x 10^8 m/s in interstellar space. However, when electromagnetic radiation travelling directly toward Earth enters Earth's atmosphere, the waves change speed and are diffracted. The change in speed and the resulting diffraction are caused by a wavelength change when the electromagnetic radiation enters Earth's atmosphere.

Which statement below identifies the **error** in this paragraph?
A. Electromagnetic radiation changes wavelength when it enters Earth's atmosphere.
B. Electromagnetic radiation travels in interstellar space.
✓C. Diffraction is the result of a change in the speed of the electromagnetic radiation when it enters a medium.
D. All wavelengths of electromagnetic radiation travel at 3.0 x 10^8 m/s in interstellar space.

35. Electromagnetic radiation of wavelength 250 m is classified as
A. ultraviolet
B. infrared
C. gamma
✓D. radio

36. If the period of an electromagnetic wave is 1.96 x 10^{-15} s, its wavelength in air is
✓A. 5.88 x 10^{-7} m
B. 1.70 x 10^{-6} m
C. 5.08 x 10^{14} m
D. 1.53 x 10^{23} m

37. X-rays can be classified as

A. long-wavelength radio waves
B. low-energy cathode rays
C. ionized gas particles
✓D. high frequency electromagnetic waves

38. A student listed some properties that he thought described characteristics of electromagnetic waves.
1. exert pressure
2. travel at light speed
3. produce interference patterns
4. have the same wavelength and frequency

Which characteristics are actually properties of electromagnetic waves?

A. 1, 2, 3, and 4
✓B. 1, 2, and 3 only
C. 2 and 3 only
D. 1 and 2 only
B

39. Which of the following regions of the electromagnetic spectrum do not overlap
A. Radar and microwave
B. Microwave and infrared
✓C. Gamma rays and ultraviolet
D. X-ray and ultraviolet

40. In the compton effect a photon of light gives up a portion of it's energy to an electron which changes it's direction. If X-ray's of 0.200000 nm wavelength are used and 0.200711 nm X-rays are found at 45º, how much energy was transferred to the electron?
answer a.b x 10^{-cd}

answer as abcd

$hc/\lambda - hc/\lambda = E$ dif = 3.52×10^{-18} J

41. A photon of wavelength 7.86×10^{-11} m strikes an electron at rest and gives 1.47×10^{-16} J of energy to the electron. The wavelength of the departing photon is

✓A. 8.3×10^{-11} m
B. 1.3×10^{-9} m
C. 2.4×10^{-15} m
D. 7.4×10^{-11} m

$hf - E_{electron} = hc/\lambda$

42. The Compton effect demonstrates
A. that X-rays are not affected by magnetic fields
B. the wave-particle duality of electrons
✓C. that photons have momentum
D. the probability of finding an electron in a specific place

43. The threshold frequency for a metal is 2.40×10^{14} Hz. What is the work function of the metal in eV?
3 marks
W=hf
1.0 eV

44. A)

If the stopping voltage applied to a photocell is 1.0 V . What would the KE of the escaping electrons be if the stopping voltage was removed.
3 marks

B)

If the metal used in the photocell has a work function of 4.0 eV, what is the frequency of light being used?
3 marks

Ke=Vq

Ke= 1.6×10^{-19} J

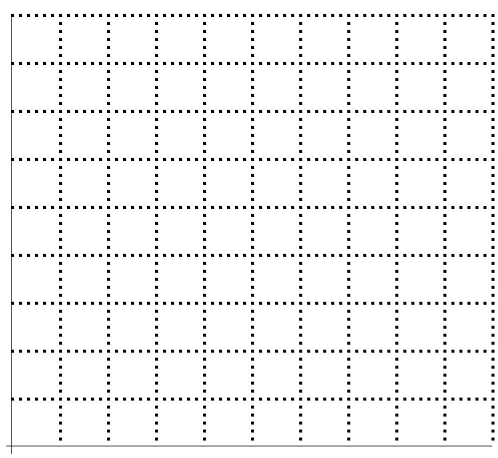
Ke=hf - Wo

hf=Ke + Wo

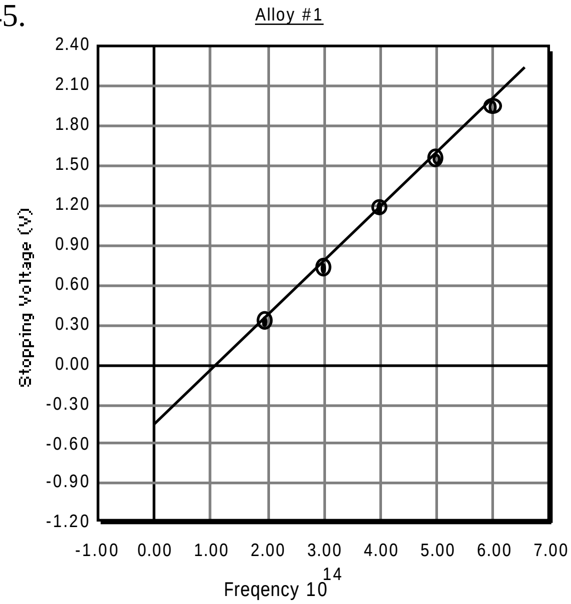
f=1.210×10^{15} Hz

45. You are an electrical engineer designing photoelectrical cells. You are creating various metal alloys for testing. You have tested your latest alloy in your testing apparatus which is allows you to vary the frequency of the incident light and measure the required stopping voltage. From the table of information collected below calculate the work function of your metal alloy, using two averaging methods. In addition explain all considerations in making the testing apparatus. (Different types of variables to control manipulate and measure and the equipment required to do it.)
(8 marks)

Incident Frequency	Stopping V
2.00×10^{14} Hz	0.325 V
3.00×10^{14} Hz	0.743 V
4.00×10^{14} Hz	1.20 V
5.00×10^{14} Hz	1.56 V
6.00×10^{14} Hz	2.02 V



45.



$f_0 = 1 \times 10^{14}$ Hz

$W_0 = hf_0$

$W_0 = 6.63 \times 10^{-34}$ Js x 1×10^{14} Hz

$W_0 = 6.63 \times 10^{-20}$ J

$W_0 = 6.63 \times 10^{-20}$ J / 1.6×10^{-19} J/eV

$W_0 =$ 0.41 eV

46. As an engineer you have been asked to specify solar panels for a new toy car. The car must be supplied with 0.5 amps using solar panels with a work function of 1.36 eV.
Assume that the average wavelength of light is 550 nm and that the car must work with as little as 300 W/m^2 of light energy.
(Assume no other losses.)

• Find the total number photons of light needed to hit the photocell to create a 0.50 amp current, asuming about 10% of the photons excite a free electron in the metal.

• Determine the an average output voltage of a single photocell given an average photon wavelength of 550 nm and a work function of 1.36 eV.

• determine the minimum frequency of photons whiich is needed to produce an electric current in the photocell.
1 marks

0.50 C/s /.1 = 5 C/s / (1.6 10^{-19} C/electron) = 3.1 x 10^{19} Photons 2marks

E=hf = 2.26 eV
2.26 - 1.36 = 0.9eV
V = 0.90 V 3 marks

$W = hf_o$

$f_o = 1.36$ eV / 4.14×10^{-15} eVs

$f_o = 3.3 \times 10^{14}$ Hz