E. Huygens principle 24-1,24-2

1) Illustrate and decribe Huygens principle. What wave behavior does it explain?

wave front = multiple wavelets of $r = vt$
tang of wavelets = future front locn
-explain : reflect, refract, Snell's

F. Interference -- Youngs double-slit experiment 24-3

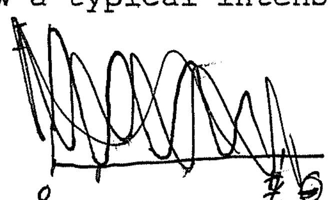
1) Read carefully how double slits produce an interference pattern. List and describe the equations for destructive and constructive interference. (** see if you can see how they were derived**)

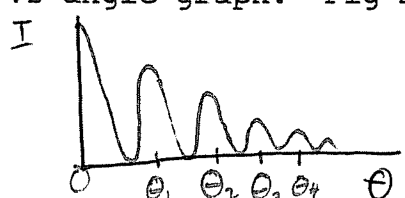
Waves interfere constructively when crest meets crest on screen. Occurs when one wavefront travels extra dist $m\lambda$ $d\sin\theta = m\lambda$

Dark caused by destructive interference as crest meets trough & $d\sin\theta = (m+\frac{1}{2})\lambda$

2) Draw a typical intensity vs angle graph. Fig 24-10

$\theta = 0$: centre fringe
$\theta_1 = m = 1$: 1st order
$\theta_2 : m = 2$: 2nd order





3) Study examples 24-1, 24-3. Note for small angles **sin@ = tan@ = x/l.**

14] The second-order fringe when 700 nm light falls on two slits is observed at a 15 deg angle to the initial beam direction. How far apart are the slits? (5.41×10^{-6} m)

$\theta_2 : m = 2$

$d\sin\theta = 2\lambda$
$d\sin 15 = 1400 \times 10^{-9}$
$d = \frac{1.4\times10^{-6}}{\sin 15} = 5.41 \times 10^{-6}$ m

15] Monochromatic light falling on two slits 0.026 nm apart produces the fourth-order fringe at a 6.4 deg angle. What is the wavelength of the light used? (7.25×10^{-13} m)

$\theta_4 : m = 4$

$d\sin\theta = m\lambda$
$\frac{.026\times10^{-9}(\sin 6.4)}{4} = 4\lambda = 7.25\times10^{-13}$ m

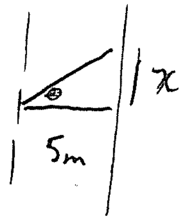
16] A parallel beam of 600 nm light falls on two small slits 0.05 mm apart. How far apart are the fringes on a screen 5.0 m away? (6.0 cm) $\theta_1 : m:1$

$d \sin\theta = 1\lambda$

$.05\times10^{-3} \sin\theta = 600\times10^{-9}$

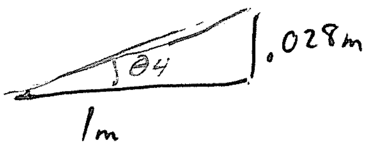
$\sin\theta = .012$

$\theta = .68$ $5\tan\theta = x = 0.060\,m$ or $6.0\,cm$



17] Light of wavelength 680 nm falls on two slits and produces an interference pattern in which the fourth-order fringe is 28 mm from the central fringe on a screen 1.0 m away. What is the separation of the two slits? (9.71×10^{-5} m) $m=4$

$d \sin\theta_4 = 4\lambda$

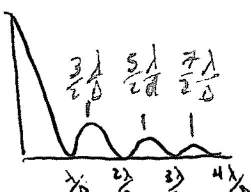


$d = \frac{4\times6.8\times10^{-7}}{\sin[\tan^{-1}(\frac{.028}{1})]} = \frac{2.72\times10^{-6}}{\sin(1.6)} = 9.72\times10^{-5}\,m$

G. The visible spectrum 24-4 UV $\lambda < 400$nm 500nm = Blue 550 = green 600nm = yellow/orange 675 = red IR $\lambda \geq 750$nm

H. Diffration by a single slit or disc 24-5

1) Draw a typical intensity vs angle graph for a single slit. Fig 24-20



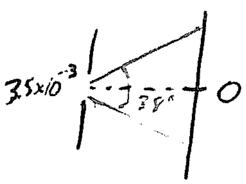
2) List and describe a formula used to calculate the interference pattern produced by a single slit. Try to determine how it was derived.

Dark: $\sin\theta = \frac{m\lambda}{D}$ — But not $m=0$

Bright: $\sin\theta = \frac{(m+\frac{1}{2})\lambda}{D}$

where D = apperture width

18] Monochromatic light falls on a slit 3.5×10^{-3} mm wide. If the angle between the first bright fringes on either side of the central maximum is 38.0 degs, what is the λ? (760 nm)



$\theta_1 = 19°$ $\sin 19 = \frac{(1+\frac{1}{2})\lambda}{D}$

$\frac{2}{3} D \sin(19) = \lambda = 760\times10^{-7}\,m$

Diffraction grating 24-6

1) What is a diffraction grating? lrg # of equally spaced parallel slits

more slits reduces m^{th} order beyond 1000's/cm

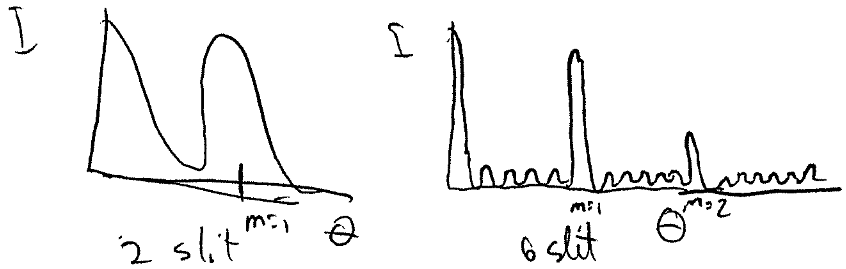
2) List and describe the formula that describes the interference pattern produced by a diffration grating.

$\sin\theta = \frac{m\lambda}{d}$ maxima

3) How is the interference pattern produced by a diffraction grating different then that produced by double slits.

Narrower maxima due to multiple slits per unit length. Creates more wave fronts all w/ differing phase & increased destructive interference

4) Draw a typical intensity vs angle graph for a difraction grating of a] 2 slits and b] 6 slits Fig. 24-24



19] The first-order line of 550 nm light falling on a diffration grating is observed at a 12 deg angle. How far apart are the slits? (2.65×10^{-6} m)

$\sin\theta = \frac{m\lambda}{D}$

$D = \frac{m\lambda}{\sin\theta} = \frac{(1)\,5.5\times10^{-7}}{\sin 12} = 2.65\,\mu m$

20] At what angle will 710 nm light produce a third-order maximum when falling on a grating whose slits are 0.0017 cm apart? (7.2 deg)

$\sin\theta = \frac{m\lambda}{D}$

$\sin\theta = \frac{3(7.1\times10^{-7})}{1.7\times10^{-5}} = 7.2^\circ$

21] How many lines per centimeter does a grating have if the third-order occurs at a 22.0 deg angle for 650 nm light? (1921 lines/cm)
find d in cm's and divide d into 1 cm

$D = \frac{m\lambda}{\sin\theta} = \frac{(3)\,6.5\times10^{-7}}{\sin 22}$

$D = 5.21\times10^{-6}$ m $= 5.21\times10^{-4}$ cm/line

$\frac{cm}{line} = \frac{1}{D} = \frac{1}{5.2\times10^{-4}}$

$= 1.92\times10^{3}$ lines/cm

J. The Spectroscope 24-7

K. Interference by thin films 24-8

1) What are some examples of interference by thin films?

see p. 739

2) **Explain how thin film interference occurs. Use Fig 24-25 to help.

light reflects off both surface layer & layer below which is a short distance further away, if 2x path thru thin layer = $m\lambda$ reflected waves constructively interfere but if $(m+\frac{1}{2})\lambda$ destruct inf. occurs

3) What are Newton's rings?

interference by thin air gap between glass when illum from above

4) Why is the point of contact of the two glass surfaces dark????

going to higher n value a light ray (or any wave) will be inverted

L. Michelson interferometer 24-9 -used to do famous Michelson-Morley experiment (Relativity) Shows no phase shift due to motion in ether ∴ no ether

Shifting length of one mirror by $\frac{1}{4}\lambda$ (doubled as path is re-traced) will destructively elim wave

M. Polarization 24-10

1) What is polarized light?

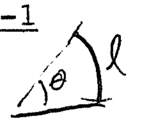
light w/ ~~propoga~~ amplitude in only 1 dimension

2) Why do polarized sunglasses help you see under the water?

reflected light off non-metal surface is polarized preferentially in plane of surface, ⊥ polarizers elim the reflective light allowing easier view of light which penetrates to depth

N. Angular Quantities 8-1

1) What is a rad?



1 rad = θ giving l = r

22] What are the following angles in radians; a) 30 deg b) 90 deg c) 420 deg? (.524, 1.57, 7.33)

$420 = 360 + 60$

$= 2\pi + \frac{\pi}{3}$

$= 2\frac{1}{3}\pi$ or $2.33\pi = 7.32$ rad

$\frac{\pi}{6}$ → .523

$\frac{\pi}{2}$ → 1.57

circ: $\pi(.68) = 2.14\,m$

.3] A bicycle with a 68 cm diamter tires travels 2.0 km. How many revolutions do the wheels make? (936 rev)

$\frac{2000}{2.14} = 936$
937 rev.

24] A 20 cm diameter grinding wheel rotates at 2000 rpm. Calculate its angular velocity in rad/s. (209 rad/s)

2000 rpm = 33.33 Hz

$\frac{2\pi\ rad}{cycle} \times \frac{33.33\ cycles}{sec} = 209\ rad/sec$

NOTE: all parts of wheel have same angular velocity, but all have different linear speed

25] List and describe a formula used to relate angular velocity to linear velocity.

$V = r\omega$

?6] What is the linear speed of a point on the edge of the grinding wheel is problem 24? (20.9 m/s)

$v = .1\,\omega$

$v = 20.9\ \frac{m}{s}$

O. Rotational dynamics; torque and rotational inertia 8-5

27] What is a moment of inertia? List formulas used to find the I for spinning masses and common objects like a hoop, cylinder, sphere & rod.

$I = \Sigma mr^2$ — rotational equivalent of mass

thin hoop: MR^2; cylinder: $\frac{1}{2}MR^2$; sphere: $\frac{2}{5}MR^2$; rod: $\frac{1}{12}mL^2$ if axial spin, $\frac{1}{3}mL^2$ if end spin

28] Calculate the moment of inertia of a 66.7 cm diameter bicycle wheel. The rim and tire have a combined mass of 1.13 kg. The mass of the hub can be ignored. Why?? (.126 kg m^2)

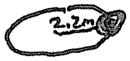
$r = \frac{.667}{2}$

$I = mr^2$
$= (1.13)(.333)^2$
$= .123\ kg\,m^2$

Why: $r = 0$ $\therefore I = 0$

read massless

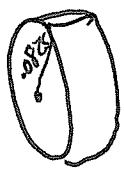
29] A small 12.4 kg ball on the end of a light rod is rotated in a horizontal circle of radius 2.20 m. Calculate the moment of inertia of the system about the axis of rotation. (60 kg m^2)



12.4 kg

$I = Mr^2$
$= 12.4(2.2)^2$
$= 60.0\ kg\,m^2$

30] A grinding wheel is a uniform cylinder of radius 8.25 cm and mass .880 kg. Calculate its moment of inertia. (2.99×10^{-3} kg m^2)



$I = \frac{1}{2}MR^2$
$= \frac{1}{2}(.88)(.0825)^2$
$= 3.0 \times 10^{-3}\ kg\,m^2$

P. Angular momentum and its conservation 8-8 (***read carefully***)

1) What is formula used to find angular momentum?

$L = I\omega$

2) What is the law of *conservation of* angular momentum?

If $\sum\tau = 0$ then L is constant (angular momentum is conserved)

31] What is the angular momentum of a 200 g ball rotating on the end of a string in a circle of radius 1.00 m at an angular speed of 9.45 rad/s? (1.89 kg m^2/s)

$I = mr^2$
$= .2 \cdot 1^2$
$= .2$

$L = I\omega$
$= .2(9.45)$
$= 1.89\ \frac{kg\,m^2}{s}$

32] A diver can reduce his moment of inertia by a factor of about 3.5 when changing from the straight position to the tuck position. If he makes two rotations in 1.5 s when in the tuck position, what is his angular speed (rev/s) when in the straight position? (.381 rev/s)

L is conserved so

$I_{tuck}\omega_{tuck} = I_{strait}\omega_{strait}$

$\frac{1}{3.5}I_s\omega_t = I_s\omega_s$

$\frac{1}{3.5}\frac{4\pi}{1.5} = \omega_s = 2.39\ \frac{rad}{sec}$

$\frac{2.39}{2\pi}$ = rotations $= 0.380\ \frac{rot}{sec}$

33] What is the angular momentum of a 2.13 kg uniform cylindrical grinding wheel of radius 12.5 cm when rotating at 1500 rpm? (2.61 kg m^2/s)

$\omega = \frac{\Delta\theta}{\Delta t} = \frac{1500 \times 2\pi}{60} = 157.1\ \frac{rad}{s}$

$I = \frac{1}{2}mr^2$
$= \frac{1}{2}(2.13)(.125)^2$
$= .0166$

$L = I\omega$
$= 2.61\ \frac{kg\,m^2}{s}$

$L = I_{(d+p)}\,\omega$

$= [1750 + 4\,65(2.25)^2](.7)$

$= 2146.375$

$L = I_d\,\omega_d$

$2146.4 = 1750\,\omega$

$\omega = 1.23\ \frac{rad}{sec}$

1] A 4.5 m diameter merry-go-round is rotating freely with an angular velocity of .70 rad/s; its total moment of inertia is 1750 kg m^2. Four people standing on the ground, each of 65 kg mass, suddenly step onto the edge of the merry-go-round. What will be the angular velocity of the merry-go-round now? What if the people were on it initially, and then jumped off? (.400 rad/s)

L is conserved (constant)

$I_{d\&people} = I_d + 4I_p$

$= 1750 + 4mr^2$

$= 1750 + 4(65)(2.25)^2$

$= 3066.25$

$\frac{L_{(d+p)}}{I_{(d+p)}} = \omega = \frac{1225}{3066} = .400\ \frac{rad}{s}$

$L_{disk} = I_d\,\omega_d = 1750(.7) = 1225\ \frac{kgm^2}{s}$

Q. <u>Magnetic field due to a straight wire 20-5</u>
<u>& Force between parallel wires 20-6 & The definition of the Ampere 20-7</u>

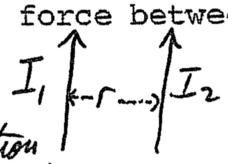
1) List and describe a formula used to determine the strength of the magnetic field around a current carrying wire. ← assume length of wire >> r

$$B = \frac{\mu_0 I}{2\pi r}$$

2) Derive a fomula used to determine the force between parallel wires.

$F = BIl$ and F per unit length

$\frac{F}{l} = BI \qquad \frac{F}{l} = \frac{\mu_0 I_1}{2\pi r} I_2$ where r is separation



3) How do you determine if the the wires will attract each other or repel each other?

RHR to determine field from each current in region between wires, opposites (field) attract [currents same way]

4) What is one ampere? ← equal amt of current flowing between 2 conductors exactly 1m apart causing force of exactly 2×10^{-7} N per unit length

35] A vertical wire carries a current of 20.0 A. What is the magnetic field strength at a distance of 5.0 cm from the wire? (8.0 x 10^{-5} T)

$B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times10^{-7}\ 20}{2\pi\ .05} = 8.0\times10^{-5}\,T$

36] Two parallel wires 50.0 m long and 12 cm apart carry a current of 36 A each ~~in the same~~ direction. How much force is there between them? is the force attractive or repulsive? (0.11 N)

$F = \frac{\mu_0 I_1 I_2\, l}{2\pi r} = \frac{2\times10^{-7}(36)^2 50}{.12} = .108\,N$

37] Two long parallel wires carry the same current in the same direction. The magnetic force of attraction between them is 4.0 μN. What will the force become if: a) both currents are doubled? b) one current is doubled and the distance between the wires is doubled? (16μN, 4.0 μN)

16μN

4μN