Drawings

The drawings in this file supplement entries in the Outline of Knowledge Database.

The Outline of Knowledge is available as a database, text file, Microsoft Word file, and PDF file at the Web link: http://www.outline-of-knowledge.info/index.html.

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space and senses

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Figure 1
The distance unit to be found is the smallest separation between sensors in the sensory array.

```
           x  -  x
           |     |
       x  -x x-  x
       |     |
       x  -  x
          d
```

Sensors have a geometric pattern. The unit distance (d) defines the unit cell in the sensory array. In the geometric pattern, unit distance separates more than one pair of points in the sensory array. All distances between sensors are proportional to the unit distance.

Sensors can displace by a distance less than or equal to the distance unit. All displacements are a proportional fraction of the unit distance. In particular, body motion or outside force can move a sensor to where another already sensor is (but no farther).

```
           x  -  x
           |     |
       x  -x x-  x
       |     |
       .  - xx
```

Minimum sensor distance = unit distance
Maximum sensory displacement = unit distance
If the sensory array is a cubic array: An edge has a unit distance.
A diagonal in a plane has distance sqr(2).
A diagonal in a cube has distance sqr(3).

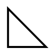
In the unit cell, the unit distance is 1. The actual unit distance is an absolute distance times the constant 1.

Brain must calculate the actual unit distance, and all actual distances, to make a spatial array model.

The relations among the distances indicate the geometry of the sensors, because all movements and distances are proportional around the center of mass. The relations among the torques and moments, in relation to gravity, internal movements, and other external forces, indicate an absolute distance. Changes of position change potential energy, which directly relates to height, and, using the center of mass, height relates to the unit distance of the sensory array.

Figure 2
Triangulation can find distances in the plane.

For right triangles, the longer side has a smaller angle with the hypotenuse and the smaller side has a larger angle with the hypotenuse.

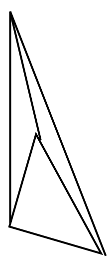


For isosceles triangles, points closer to the base have a bigger angle at the apex and smaller angles at the base.

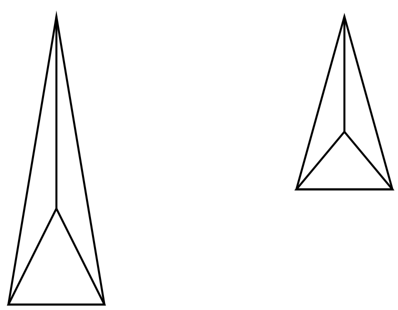
Because the two points at the base of an isosceles triangle are equivalent and all angles have specific relations in a right triangle, triangulation does not give enough relations to find the actual unit distance in a sensory array.

"Tetrahedralation" can find distances in three-dimensions.

For symmetric right tetrahedrons, the base is an isosceles right triangle and other sides are right triangles.



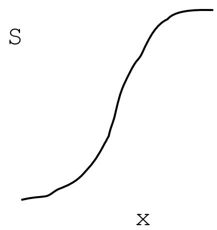
For isosceles tetrahedrons, points closer to the base have a bigger angle at the apex and smaller angles at the base.



Because an isosceles tetrahedron can have different isosceles triangles on different faces, and the isosceles tetrahedral faces have specific relations, tetrahedralation does give enough relations to find the actual unit distance in a sensory array.

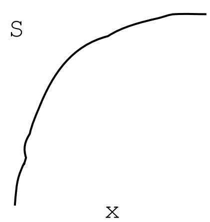
Note: Therefore, brain can make only three-dimensional or higher-dimensional spaces, because fewer dimensions do not give enough information to find absolute distance.

Figure 3
The function of stimulus to distance might be a sigmoid curve.



S = 1/(1 + e^-x)
(-10,0) (-1,-0.3) (0,0.5) (1,0.7) (10,1)

The function of stimulus to distance might be a logarithmic curve.



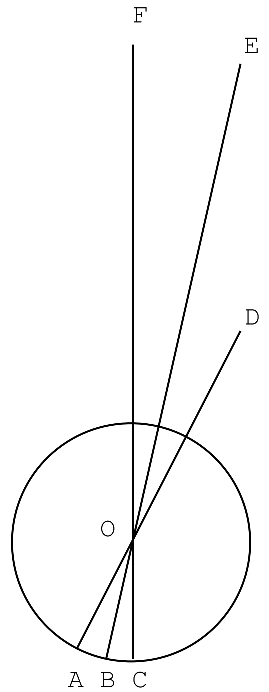
S = ln(x)
(1,0) (e,1) (e^2,2) (e^3,3) (e^4,4)

Sensor displacement (x) causes a stimulus to be sent to the sensory and then brain array.

The maximum sensor displacement is x, and this causes the maximum stimulus.

The maximum stimulus relates to the unit distance between sensors.

Figure 4
For all senses, stimuli occur in (larger) space and converge on a compact array of neurons.



An eye lens converges light rays onto the retina. The retina sends an array of signals to a neural array of similar compactness.
An ear system converges sound waves onto the hair cells in the cochlea. The hair cells send an array of signals to a neural array of similar compactness.
Touch sensors on the body and kinesthetic sensors in the body converge stimuli on topological brain regions.
Smell and taste receptors converge stimuli on organized brain regions of similar compactness.

Nerve signals cross all chemical synapses in the same (slower) time.
Nerve signals cross all electrical synapses in the same (faster) time.
The number of synapses between two places directly relates to time.

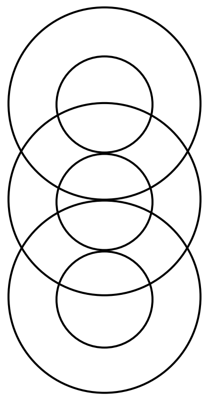
Nerve signals in unmyelinated axons have the same (slower) velocity.
Nerve signals in myelinated axons have the same (faster) velocity.

The time between neural events depends on the number and type of synapses and lengths and types of axons.

The unit of distance measurement for brain is the distance between neighboring cells. Distances directly relate to times.
The unit of time measurement for brain is the time for a signal to travel in a myelinated fiber between two neighboring cells and cross a chemical synapse (or in an unmyelinated fiber then crossing an electrical synapse).

Note: Nervous system uses cellular clock mechanisms to send timing and synchronizing signals.

Figure 5
Timing also involves alternating excitation and inhibition.



First, a previous-level neuron for the same position in space, in the center of the receptive field, excites a neuron. Previous-level neurons for nearby positions in space, in the surround of the receptive field, inhibit the neuron. The stimuli pass straight through.

Second, the previous-level neuron for the same position in space, in the center of the receptive field, no longer excites a neuron. Same-level interneurons that receive from same-level neurons for nearby positions in space inhibit the neuron. Feedback inhibition also occurs. Boundaries between adjacent points sharpen for better discrimination. Also second, the neuron excites a next-level neuron. Same-level neurons for nearby positions in space, in the surround of the receptive field, inhibit the next-level neuron. The stimuli pass straight through.

Third, the previous-level neuron for the same position in space, in the center of the receptive field, no longer excites a neuron. Same-level interneurons that receive from same-level neurons for nearby positions in space no longer inhibit the neuron. Same-level interneurons from same-level neurons for far positions in space inhibit the same-level interneurons that receive from same-level neurons for nearby positions in space. Feedback inhibition of feedback inhibition also occurs. Links between adjacent regions make better generalization. Also third, the same-level neuron for the same position in space, in the center of the receptive field, no longer excites the next-level neuron. Next-level interneurons that receive from next-level neurons for nearby positions in space inhibit the next-level neuron. Feedback inhibition also occurs. Boundaries between adjacent points sharpen for better discrimination.

Fourth, the same-level neuron for the same position in space, in the center of the receptive field, no longer excites the next-level neuron. Next-level interneurons that receive from next-level neurons for nearby positions in space no longer inhibit the neuron. Next-level interneurons from next-level neurons for far positions in space inhibit the next-level interneurons that receive from next-level neurons for nearby positions in space. Feedback inhibition of feedback inhibition also occurs. Links between adjacent regions make better generalization.

Note: Neurons maintain stimulus intensity over all distances.

Figure 6
If only internal forces operate on a flexible structure, the center of mass does not change. If an outside force operates, the center of mass moves.

In equilibrium, torques balance. Torques are proportional to distance and to force. The shape of an object around the center of mass determines the torques caused by gravity. When shape changes, torques change. Outside tangential forces might change the angles between parts of an object by moving the masses.

The shape of an object around the center of mass determines the moments of inertia. When the shape changes, the moments change. Radial forces change the moments by moving masses. Moments are proportional to distance squared and to mass.

Body movements do not move the center of gravity. Body movements can change the torques and moments. The center of gravity and any torques and moments provide equations of motion and energy that can help determine the unit distance in a sensory array. Changing or maintaining the center of gravity, torques, and moments only changes the system linearly, so one can find only relative distance.

This example sensory array originally has equal spacing (11) between sensors.

```
Torques and Moments around Center of Mass
                                  A          B           C          D
                             2221111111111000000000 0000000001111111111222
                             2109876543210987654321|1234567890123456789012
Original                   :      x          x     |     x          x
torque = 23 moment = 325          17         6     |     6         17
Only nearest compensates   :      x               x|x               x
torque = 18 moment = 290          17              1|1              17
Only two nearest compensate:    x                 x|  x             x
torque = 20 moment = 382/297    19                1|  3            17
All compensate             : x                    x|x                    x
torque = 23 moment = 485     22                   1|1                   22
Torques same               : x                    x|x                    x
torque = 23 moment = 485     22                   1|1                   22
Moments same               :     x                x|     x          x
torque = 19/23 moment = 325     324               1|    36         289
```

Distances between Sensors

	AB	BC	CD
Original :	11	11	11
Only nearest compensates :	16	00	16
Only two nearest compensate:	18	02	14
All compensate :	21	00	21
Torques same :	21	00	21
Moments same :	17	04	11

Body movements involve a body part. Nearby body parts, or all body parts, react to any change and coordinate with any change. The coordination among body parts in a body movement provides equations of motion and energy that can help determine the unit distance in a sensory array.

A body has a lever with a mass. A longer lever has more torque. Changing body positions changes both the radius and the mass. The extra variable prevents knowing the absolute distance.

The kinesthetic system and touch system learn the equations about center of mass, torques, and moments, as well as coordination of body parts, for both internal and external forces.

Figure 7
The sensory array has a regular arrangement, and so do the neural arrays in brain. The neural arrays have the same small and equal spacing between neurons.

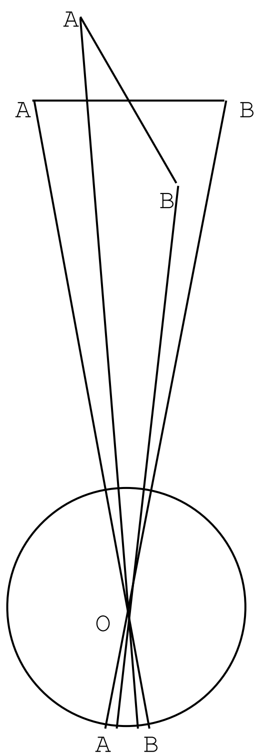
	AB	BC	CD
Original sensory array:	11	11	11

	AB	BC	CD
Neural array:	0.01	0.01	0.01

	AB	BC	CD
Spatial array model:	11	11	11

Perhaps the spatial array model starts with the same small and equal spacing among cells as in the neural array. Calculations using many stimuli in many different configurations of sensory arrays find the actual unit distance in the original sensory array and use that distance in the spatial array model.

Figure 8
A surface has higher intensities at larger angles.



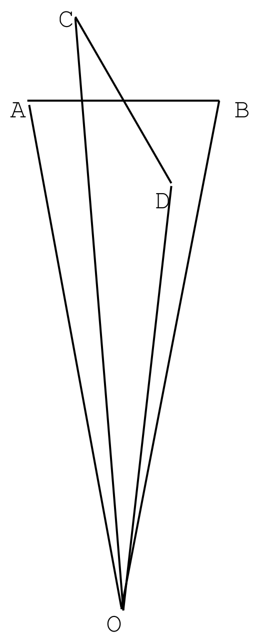
A surface reflects light equally in all directions. The total light seen when looking at a perpendicular surface is the same as when looking at an angled surface.

However, the surface area seen is larger when looking at a perpendicular surface than when looking at the same surface at an angle. The angle seen is larger when looking at a perpendicular surface than when looking at the same surface at an angle.

The intensity is more for an angled surface.

You can verify this by looking at a surface at different angles.

Figure 9
A source illuminates a surface with higher intensities at smaller angles.



A source radiates light equally in all directions. The total light landing on a surface depends on the angle made by the edges.

The angle (AOB) is larger for a perpendicular surface than for the same surface at an angle (COD).

However, the surface areas are the same.

The intensity is more for a perpendicular surface.

You can verify this by looking at a surface at different angles to a source.

1>Consciousness>Sense>Hearing>Music
tone in music

1/Consciousness/Sense/Hearing/Music/tone in music.html

Figure 1

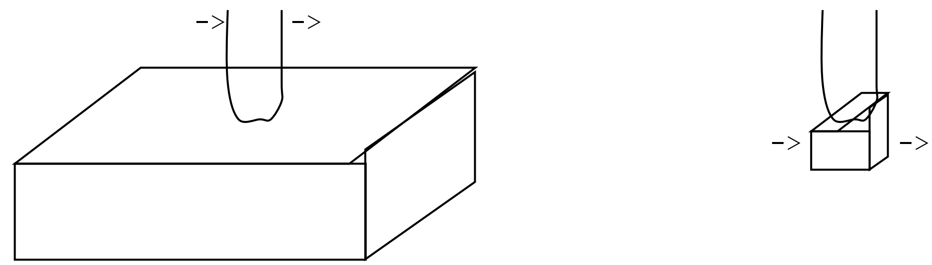
Ascending and Descending Frequency Ratios,
Equal-Temperament-Scale Base-Two Logarithms, and Tones

Asc Ratio	Desc Ratio	Asc	Logarithm		Desc	Asc Note	Desc Note
1/1	2/1	1.00	= 2^0.000	2^1.000 =	2.00	C	C
13/12	15/8	1.06	= 2^0.083	2^0.916 =	1.89	C#	B
12/11	11/6	1.09			1.83		
11/10	9/5	1.10			1.80		
10/9	9/5	1.11			1.79		
9/8	9/5	1.13	= 2^0.166	2^0.833 =	1.78	D	A#
8/7	7/4	1.14			1.75		
7/6	12/7	1.17			1.71		
6/5	5/3	1.19	= 2^0.250	2^0.750 =	1.68	D#	A
5/4	8/5	1.26	= 2^0.333	2^0.667 =	1.59	E	G#
		1.30			1.54		
4/3	3/2	1.34	= 2^0.416	2^0.583 =	1.49	F	G
11/8		1.38			1.45		
7/5	7/5	1.41	= 2^0.500	2^0.500 =	1.41	F#	F#
	11/8	1.45			1.38		
3/2	4/3	1.49	= 2^0.583	2^0.416 =	1.34	G	F
		1.54			1.30		
8/5	5/4	1.59	= 2^0.667	2^0.333 =	1.26	G#	E
5/3	6/5	1.68	= 2^0.750	2^0.291 =	1.19	A	D#
12/7	7/6	1.71			1.17		
7/4	8/7	1.75			1.14		
9/5	9/8	1.78	= 2^0.833	2^0.166 =	1.13	A#	D
9/5	10/9	1.79			1.11		
9/5	11/10	1.80			1.10		
11/6	12/11	1.83			1.09		
15/8	13/12	1.89	= 2^0.916	2^0.083 =	1.06	B	C#
2/1	1/1	2.00	= 2^1.000	2^0.000 =	1.00	C	C

1>Consciousness>Sense>Touch>Physiology
haptic touch

1/Consciousness/Sense/Touch/Physiology/haptic touch.html

Figure 1
Touch can tell whether a surface is sliding by stationary skin or skin is sliding over a stationary surface.



Stationary Surface and Moving Finger   Stationary Finger and Moving Surface

Most objects connect to the ground and are stationary. Their connection to the ground makes them have high inertia and no acceleration when pushed or pulled.

Objects that slide past stationary skin have inertia similar to or less than the body. (If large object slide by skin, the collision affects the whole body, not just the skin.) They have measurable deceleration when pushed or pulled.

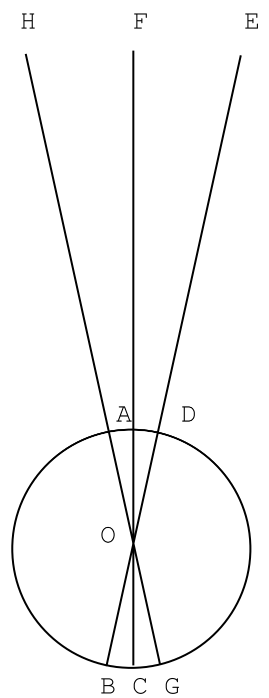
The touch system measures accelerations and decelerations in the skin. Large decelerations in skin result from sliding by stationary objects. Small decelerations in skin result from objects sliding by skin.

The touch system can detect whether objects are stationary. It uses this knowledge, together with information from the kinesthetic system (including the vestibular system) to build the stationary three-dimensional spatial array known to consciousness.

1>Consciousness>Sense>Vision>Physiology>Depth Perception distance ratio

1/Consciousness/Sense/Vision/Physiology/Depth Perception/distance ratio.html

Figure 1
A single eye can find the ratio of object size to distance by looking at three points of the object.



The eye fixates on a point (F) at the center of an object, on an edge (E) of the object, and on the opposite edge (H) of the object.

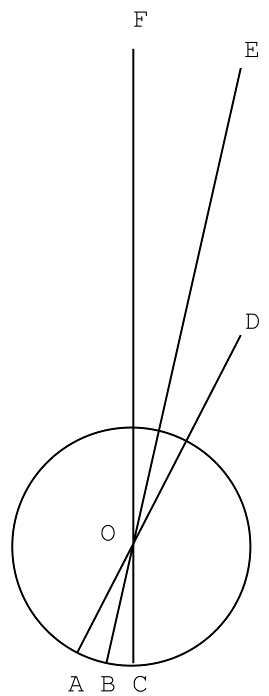
Assume the object (HFE) is perpendicular to the line of sight (CF). Assume the retina (BCG) is a plane. Assume that a spherical eye rotates around its center (O) with a radius to determine (OC = OB = OG). The light rays go from the object's center point (F) to the retina (C), the edge point (E) to the retina (B), and the opposite edge point (H) to the retina (G).

tan(angle BOC) = BC/OC = FE/OF and tan(angle GOC) = CG/OC = HF/OF
BG/OC = HE/OF and HE = HF + FE and BG = BC + CG

Using the kinesthetic and touch systems, and motor cortex, the brain knows the visual angles and the distances between projections on the retina.

Solving the equations can find the ratio of object size to distance (HE/OF).

Figure 2
When the eye rotates, the scene does not change (except for focus).



When looking at point F, point F in space projects to point C at the fovea on the retina. Point E in space projects to point B to the left of point C on the retina. Point D in space projects to point A to the left of point B on the retina.
When looking at point E, point E in space projects to point B at the fovea on the retina. Point F in space projects to point C to the right of point B on the retina. Point D in space projects to point A to the left of point B on the retina.
When looking at point D, point D in space projects to point A at the fovea on the retina. Point E in space projects to point B to the right of point A on the retina. Point F in space projects to point C to the right of point B on the retina.

The location of the projection of the scene on the retina changes, but the order of points stays the same. The scene looks the same in all cases, except for the focus.

You can verify this by looking at a point, then a nearby point, and then the first point again. You feel a scene shift but see no change in the scene. The scene periphery appears to change somewhat, because the eye is only approximately spherical and the lens has spherical aberration.

Figure 3

Adjacent Retinal Receptors Subtend the Same Angle, with No Overlap

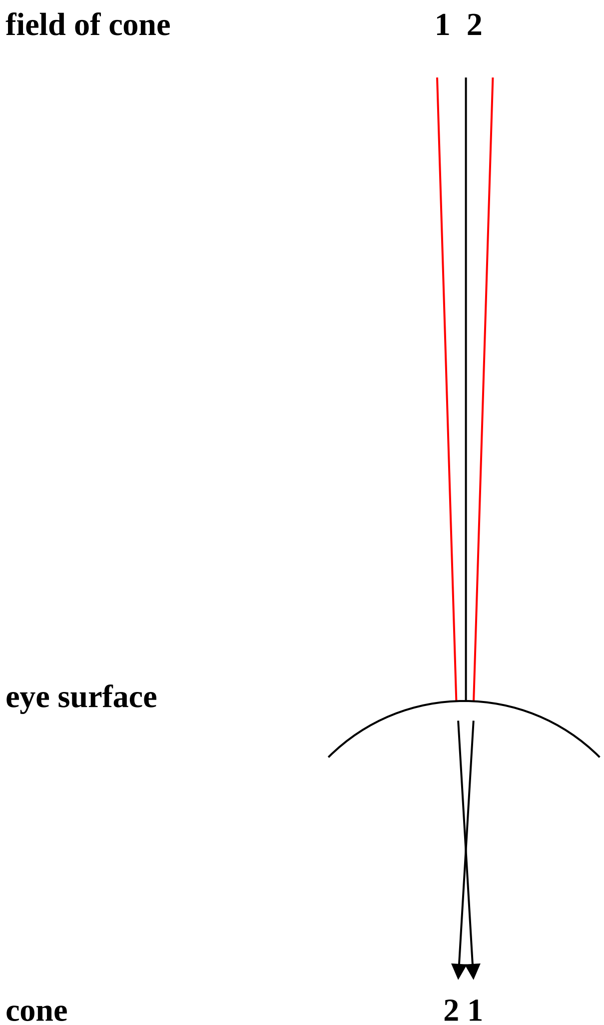
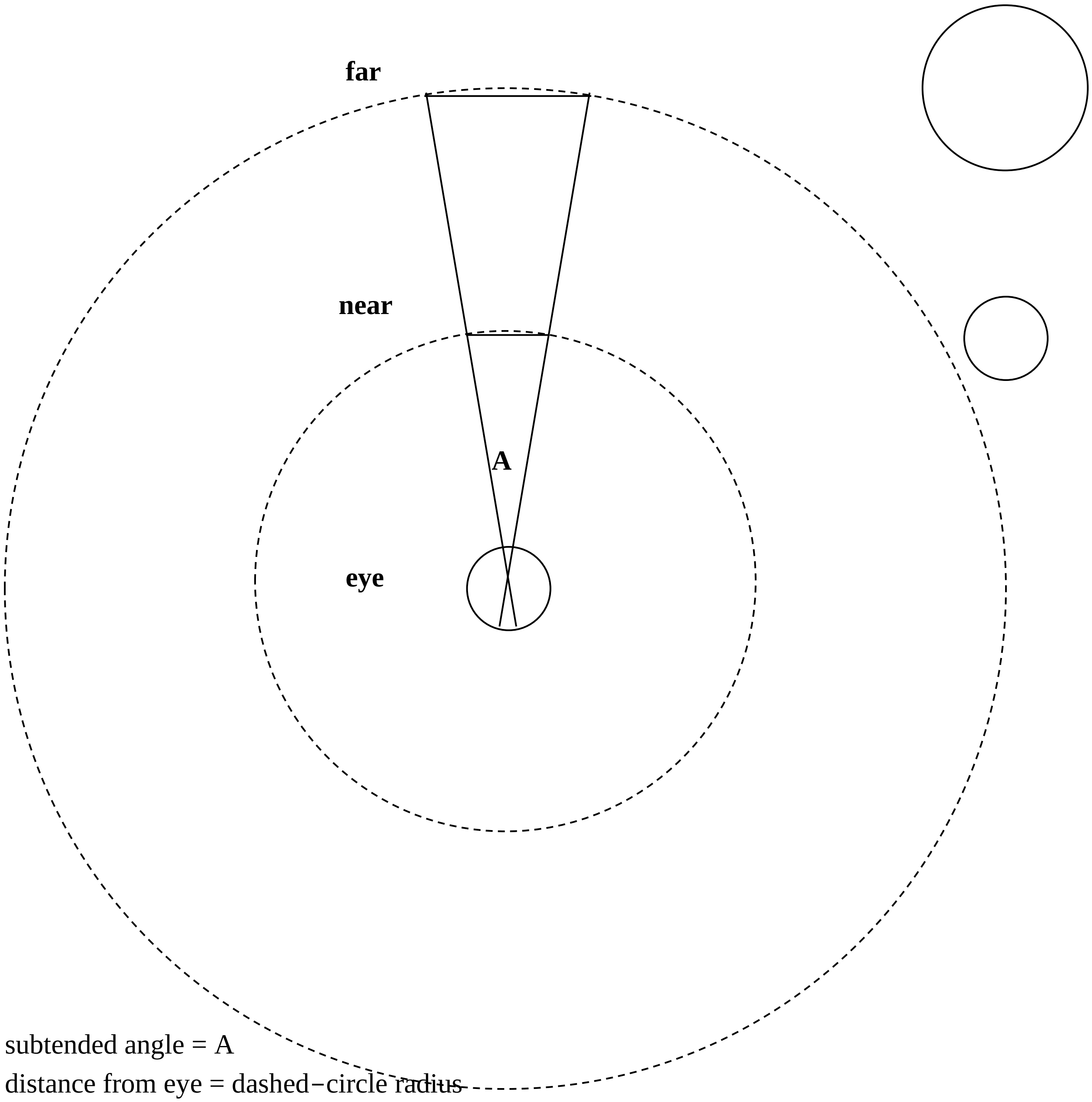


Figure 4

For Same Subtended Angle, Circular Surfaces at Different Distances Have Different Diameters, Areas, and Circumference Curvatures



subtended angle = A

distance from eye = dashed−circle radius

dashed−circle radius = subtended arc / subtended angle

subtended arc ~ undashed−circle diameter

distance from eye ~ undashed−circle diameter / subtended angle

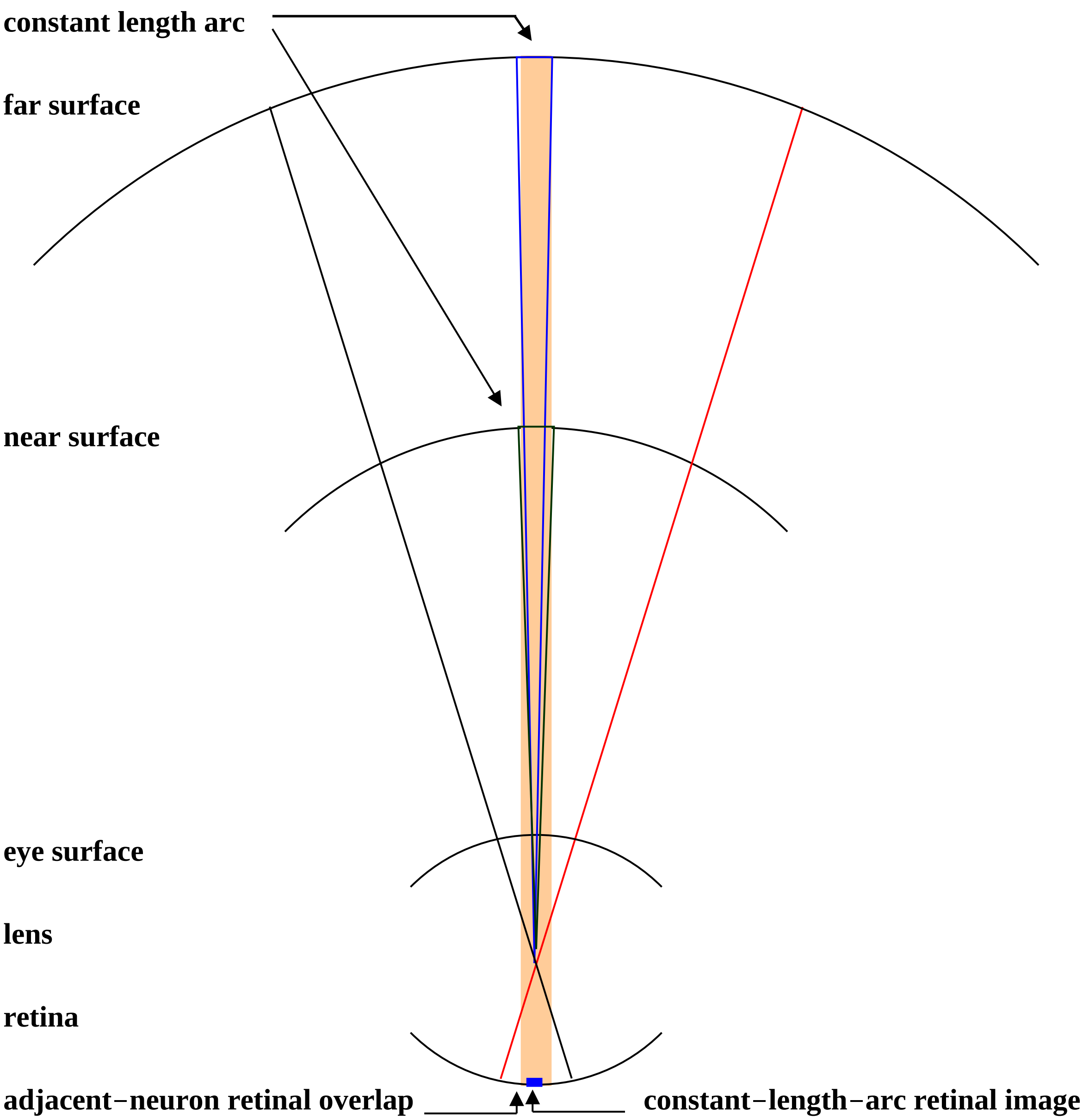
undashed−circle diameter = 2 * undashed−circle radius

undashed−circle area = 2 * π * undashed−circle radius

undashed−circle curvature = 1 / undashed−circle radius

Figure 5

Comparing Adjacent Neuron Arrays Calculates Constant Length and Constant−Length Subtended Angle, Allowing Distance Calculation



Black and tan lines have same subtended angle as red and tan lines, and all lines meet at lens.

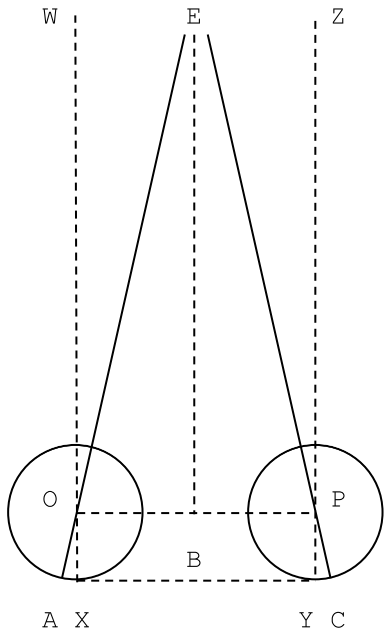
Blue lines come from ends of farther constant−length arc, and green lines come from ends of closer constant−length arc. At farther distances, constant−length arc subtends smaller angle and smaller retinal image.

Adjacent neuron arrays have retinal overlap, and retinal and cortical neuron−array overlap defines a constant length. Constant−length−arc retinal−image size defines the subtended visual angle, which varies inversely with distance, allowing calculating distance to surface in one step: distance = radius = arc length / subtended angle = constant length / subtended angle

1>Consciousness>Sense>Vision>Physiology>Depth Perception triangulation by eye

1/Consciousness/Sense/Vision/Physiology/Depth Perception/triangulation by eye.html

Figure 1
Two eyes can measure relative distance to a point by triangulation.



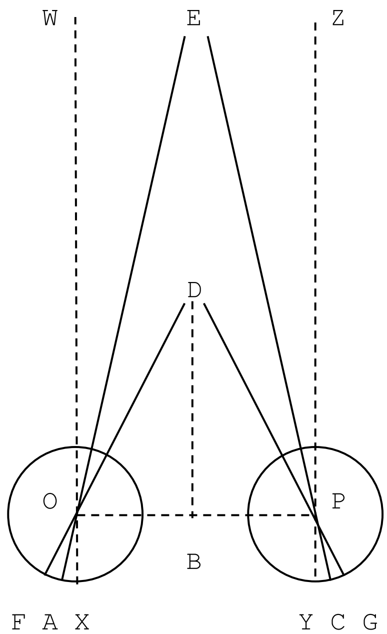
Two eyes have a distance between them (XY = OB + BP = 2 * OB).
eye radius = OX = OA = PY = PC
Point E is EB from the line between the eyes and OE (= PE) from the center of each eye and AE (= CE) from the retina of each eye.
When the eyes look at a point on the line between the eyes (E), both eyes have the same angle of convergence (angle EOW = angle EPZ).
angle EOW = angle OEB = angle AOX (= angle EPZ = angle PEB = angle CPY)
angle AOX = AX/OX = YC/PY = angle CPY
tan(angle OEB) = OB/EB = PB/EB = tan(angle PEB)
sin(angle OEB) = OB/OE = PB/PE = sin(angle PEB)

The kinesthetic system can find the convergence angles by measuring eye muscle tension and so can calculate the distance relative to eye separation distance.

Using two eyes makes a triangle (EOP and EAC), and the length of a side can be found using its opposite angle and another side and its opposite angle (law of sines): (sin(pi/2 - angle OEB))/OE = (sin(2*angle OEB))/XY
OE/XY = (sin(pi/2 - angle OEB))/(sin(2*angle OEB))
The length of a side can also be found from two other sides and the angle between them (law of cosines):
OE^2 = OE^2 + XY^2 - 2*OE*XY*cos(pi/2 - angle OEB)
2*OE*XY*cos(pi/2 - angle OEB) = XY^2
OE/XY = 1/(2*cos(pi/2 - angle OEB))

From the angle of convergence, one can calculate distance relative to eye separation distance.

Figure 2
Comparing triangulations from two different distances does not give more information.



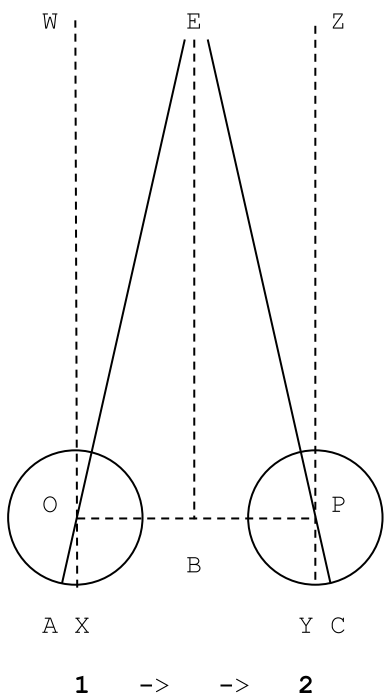
Two eyes keep the same distance between them (XY = OB + BP = 2 * OB).
At the nearer distance, the angle of convergence is more:
angle EOW < angle DOW

Two triangulations make two equations:
OE = XY/2*cos(pi/2 - angle PEB)
OD = XY/2*cos(pi/2 - angle PDB)

However, the new equation has a new variable, so one cannot calculate absolute distance XY. Using two eyes, one can calculate only relative distances.

Note: Moving the eye off the plane made by the line between the two points adds a new variable, the distance above the plane, so one still cannot calculate the absolute distance. Using two eyes, one can calculate only relative distances.

Figure 3
An eye moving sideways while tracking a point in space can calculate the distance from the eye to the point, using triangulation.



If an eye moves a distance XY from position 1 to position 2 while looking at a point (E) in space, the point E in space always projects to the fovea on the retina (point A in position 1 and point C in position 2).

The angle to the straight-ahead direction changes from angle WOE to angle ZPE and angle WOE = angle ZPE.

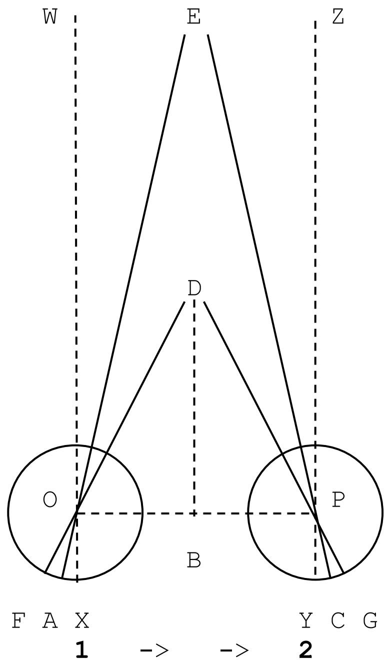
The spatial situation is the same as in Figure 4, so:
OE = XY/2*cos(pi/2 - angle PEB)

The distance moved XY is findable because the organism moved through space and the kinesthetic system finds the distance between the eyes. The kinesthetic system finds the eye angles by measuring eye muscle or head muscle tension.

Movement of one eye can find the distance of a point.

Closer objects require the eye to turn through more angle, helping to calibrate the angle.

Figure 4
An eye moving sideways while tracking a point in space calibrates distances because any other point in space travels across the retina.



If an eye moves a distance XY from position 1 to position 2, while looking at a point (E) in space, the point D in space first projects to point F to the left of point A at the fovea on the retina, then projects to point G to the right of point C at the fovea on the retina.

The projection of point D travels across the retina through the fovea. The retina knows the distances AF = CG. The kinesthetic system knows the angle WOE = angle ZPE.

The roles of point E and D can reverse by tracking D instead of E. The projection of point E then travels across the retina through the fovea. The retina knows the distances AF = CG. The kinesthetic system knows the angle WOD = angle ZPD.

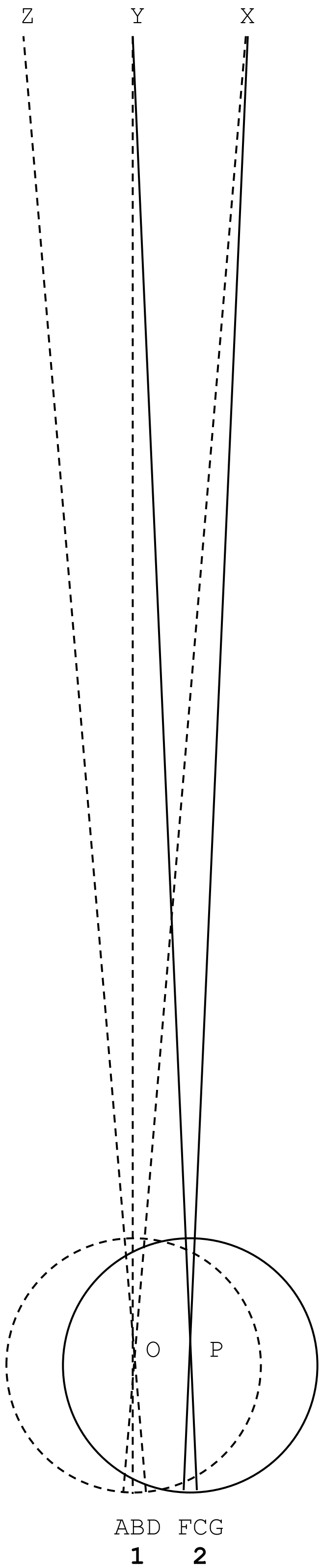
The distances AF and CG define the angle between points D and E and the center of the eye (angle EOD = angle EPD). The distance is proportional to the difference of position or angle.

The spatial situation is the same as in Figure 4, so:
OE = XY/2*cos(pi/2 - angle PEB)
OD = XY/2*cos(pi/2 - angle PDB)

Now brain knows the distance moved XY, and the angles PEB and PDB, and both can corroborate the other.

So the distances of points can be calibrate by movement of one eye.

Figure 5
If an eye looks at an object rather than just a point, moving the eye from looking straight at the edge to looking straight at the middle can determine the distance of a point in space.



The eye (dashed circle) at position 1 is looking at point Y, which projects to point B at the fovea on the retina. Point X in space projects to point A to the left of point B on the retina.
The same eye (solid circle) at position 2 has moved sideways to the right a distance of BC (= XY/2) and turned to the left to look at point Y, which projects to point G at the fovea on the retina. Point X in space projects to point F to the left of point G on the retina.
At position 2, the distance YX looks maximum (FG). FG = AB because XY = ZX/2 and AD = 2 * FG.

YX = distance between points in space
BC = YX/2 = distance between eye positions
FX = GY = distance from retina to points in space
PY = PX = distance from center of eye to points in space
radius of eye = OA = OB = PF = PG = PC
AB = FG
angle of turning = (angle FPG)/2 = (FG/FP)/2
$BY^2 + (BC + FG/2)^2 = GY^2$
$BY/\sin(\pi/2 - (FG/FP)/2) = (BC + FG/2)/((FG/FP)/2)$

The visual system knows the distance between retinal points. The kinesthetic system knows the sideways distance and the turning angle. One then can calculate eye radius.

Sideways eye movement can maximize the length seen for an object in space by moving to the point of view that looks straight at the middle of the object. Sideways eye movement can find the point of view that looks straight at the left side of the object and the point of view that looks straight at the right side of the object, because the two points make equal but opposite angles around the projection from the middle of the object.

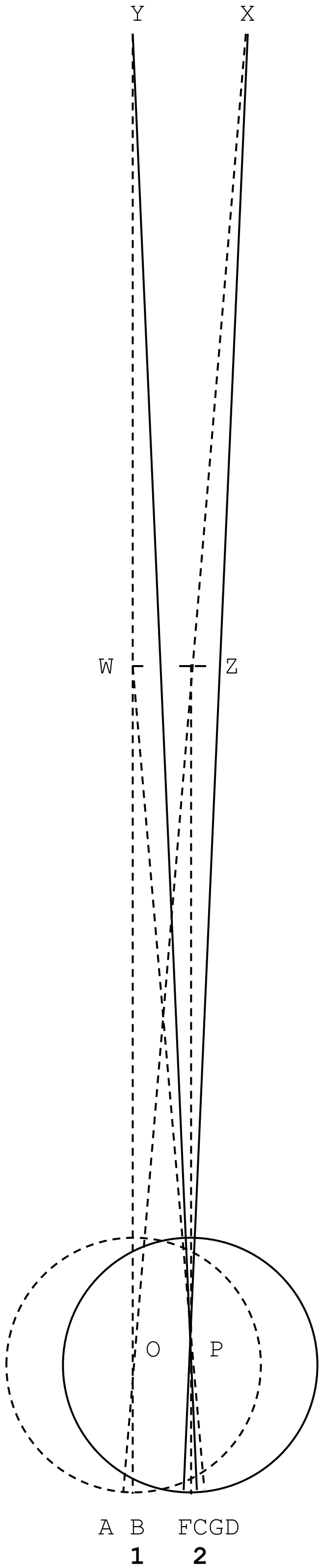
Sideways eye movement can determine the distance of a line segment in space from the eye by comparing the point of view that looks at the side of an object and the point of view that looks straight at the middle of the object.

Sideways eye movement can determine the orientation of a line in space.

Note: The eye can move along the length of the object or across the length of the object.

Note: As an eye rotates in a direction, it also slides in the other direction, because the muscles thicken on the rotated-toward side and lengthen on the rotated-away-from side.

Figure 6
If an eye looks at an object rather than just a point, moving the eye from looking straight at one edge to looking straight at the other edge (assumed to be at the same distance) can determine distance of a point.



Line segment WZ is halfway to line segment YX. WZ = (2/3) * XY.

At position 1, W projects to B and Z projects to A with A to the left of B.
At position 2, W projects to D and Z projects to C with C to the left of D.
radius of eye = OA = OB = PF = PG

In position 1, eye looks straight ahead at W.
In position 2, eye looks straight ahead at Z.
The two situations are the same.
AB = CD
BC = AZ

The visual system knows the distance between retinal points. The kinesthetic system knows the sideways distance (turning angle is zero). One then can calculate eye radius.

Sideways eye movement can find the point of view that looks straight at the left side of the object and the point of view that looks straight at the right side of the object, because the two points make equal but opposite angles around the fovea on the retina.

Sideways eye movement can determine the distance of a line segment in space from the eye by comparing the point of view that looks at the right side of an object and the point of view that looks straight at the left side of the object.

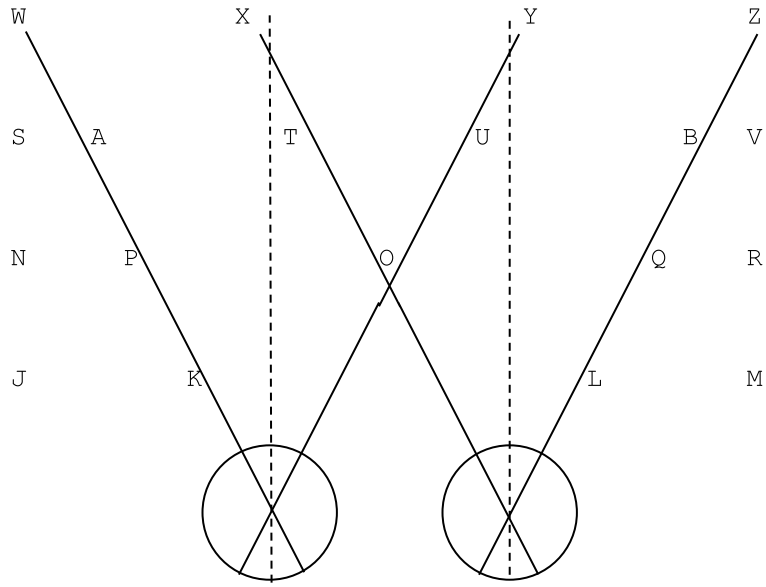
Sideways eye movement can determine the orientation of a line in space.

Note: The eye can move along the length of the object or across the length of the object.

1>Consciousness>Sense>Vision>Physiology>Depth Perception>Cue binocular depth cue

1/Consciousness/Sense/Vision/Physiology/Depth Perception/Cue/binocular depth cue.html

Figure 1
Brain can judge distance by the overlap, total area, and rate of change of area seen by two eyes.



When looking at a surface (WZ, SV, NR, JM), each eye sees a semicircle of the surface. The front edge of the surface is the diameter of the semicircle (WZ, SV, NR, JM), and the field of vision above that line is the circumference of the semicircle. The semicircles of both eyes overlap in the middle (XY, TU, O, none).

Closer surfaces (JM, NR) make the overlap less (none, O), and farther surfaces (WZ, SV) make the overlap more (XY, TU).

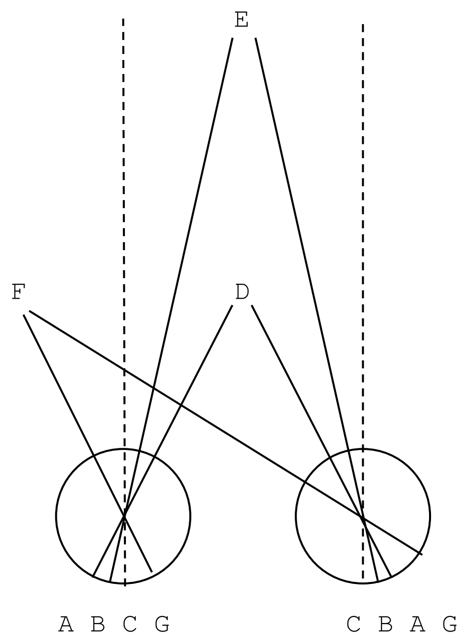
The total area is more for farther surfaces (WZ, AB) and less (KL, PQ) for closer surfaces.

Movement changes the areas seen at a rate dependent on distance. Closer objects (JM to NR) change area faster (KL to PQ) and farther objects (SV to WZ) change area slower (AB to WZ).

1>Consciousness>Sense>Vision>Physiology>Depth Perception>Cue convergence of eyes

1/Consciousness/Sense/Vision/Physiology/Depth Perception/Cue/convergence of eyes.html

Figure 1
The eyes converge more to look at closer points.



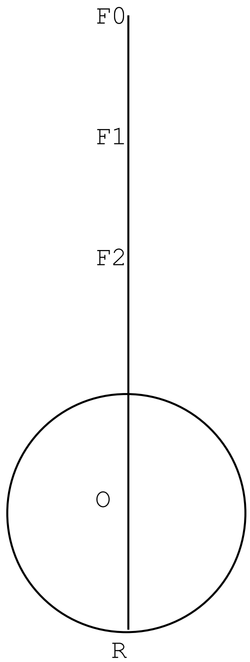
For a very far point (dashed lines), the eyes do not converge and the point lands on both foveas (C).
For a far point (E), the eyes converge somewhat to make the point land on both foveas (B).
For a near point (D), the eyes converge more to make the point land on both foveas (A).

Notes:
When the eyes look at a very far point, nearer points between the eyes project more toward the outer edge of the retina than farther points.
When the eyes look at a far point, nearer points between the eyes project toward the outer edge of the retina and very far points between the eyes project toward the inner edge of the retina.
When the eyes look at a near point, very far points between the eyes project more toward the inner edge of the retina than far points.
Points (F), not between the eyes, project to points (G) toward the inner edge of closer retina and outer edge of farther retina.

1>Consciousness>Sense>Vision>Physiology>Depth Perception>Cue intensity difference during movement

1/Consciousness/Sense/Vision/Physiology/Depth Perception/Cue/intensity difference during movement.html

Figure 1
Changes in intensity during movement toward and away from a surface can find relative distance.



Moving from a point (F0) to its halfway point (F2) increases the intensity four times, because the eye gathers four times more light at the closer radius. Moving from a point (F2) to its double point (F0) decreases the intensity four times, because the eye gathers four times less light at the farther radius.

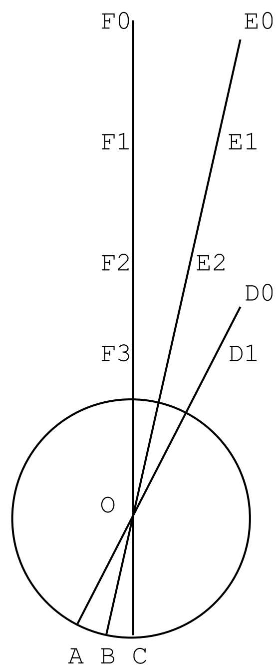
Movement side to side and up and down changes the intensity slightly by changing the distance slightly. Perhaps saccades and/or eyeball oscillations help determine distances.

Experience with objects of constant intensity establishes their distances.

Atmospheric haze also affects light intensity. Haze decreases intensity proportionally with distance. An object twice as far away has half the intensity.

You can verify this by looking at a candle while moving it closer and farther. You may feel tightening and loosening of the eye pupil muscles. You will see looming (or receding), as more (or less) visual angle sends light to the eye.

Figure 2
Points of a scene along the same light ray project to the same point on the retina.



Points F0, F1, F2, and F3 project to point C on the retina.
Points E0, E1, and E2 project to point B on the retina.
Points D0 and D1 project to point A on the retina.

Though their distances are different, the points along a light ray project to the same point on the retina. If intensities at points along a light ray increase with the square of the distance, the points along a light ray look the same, except for focus, because intensity decreases with square of the distance.

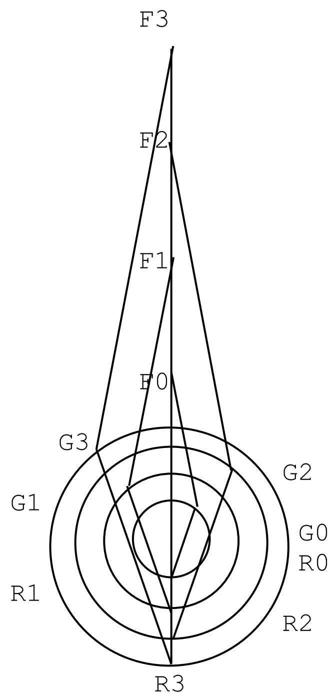
You can verify this directly by moving a point closer to the eye or moving the head closer to the point, keeping the point on the fovea.

Note: A real scene maintains the distances among its points in space, so, if it comes closer, it looks magnified, and, if it moves farther away, it looks smaller. If all points of a scene could come closer along their light rays, the distances among the points in space would decrease. If all points of a scene could go farther out along their light rays, the distances among the points in space would increase.

1>Consciousness>Sense>Vision>Physiology>Focusing accommodation

1/Consciousness/Sense/Vision/Physiology/Focusing/accommodation.html

Figure 1
A single eye can measure distance by the amount of focusing required.



To focus on point F3, the lens must have the least curvature.
To focus on point F2, the lens must have a little more curvature.
To focus on point F1, the lens must have more curvature.
To focus on point F0, the lens must have the most curvature.

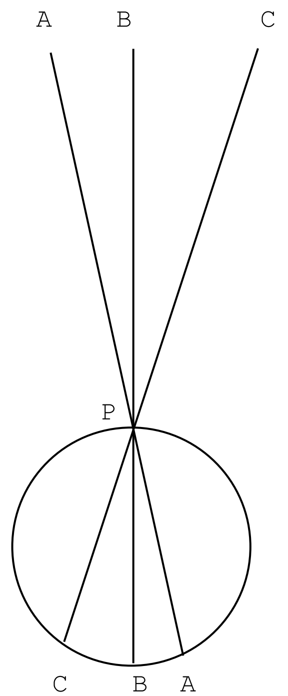
The amounts of curvature (C3, C2, C1, C0) directly relate to the distances R3G3, R2G2, R1G1, R0G0, because the angles of refraction are the same.
The distances R3G3, R2G2, R1G1, R0G0 directly relate to the distances F3G3, F2G2, F1G1, F0G0 and R3F3, R2F2, R1F1, R0F0, because the angles of refraction are the same.

The amount of curvature directly relates to the distance of the point from the retina.

The kinesthetic system can find the lens curvature by measuring lens muscle tension, so one can calculate distance relative to lens curvature.

You can verify this by looking at a point, then a nearer point. You feel tightening of the lens muscles.

Figure 2
A pinhole camera can focus a scene, but the eye is not a pinhole camera.



A pinhole (P) allows only one ray of light from a point to enter and project straight to the back.

A pinhole camera is dim, because a pinhole is small and little light enters.

A lens gathers light from a point over its area and focuses all those light rays onto a single point.

The eye gathers light using its lens and controls the amount of light using its pupil.

1>Consciousness>Sense>Vision>Physiology>Focusing
binocular disparity

1/Consciousness/Sense/Vision/Physiology/Focusing/binocular disparity.html

Figure 1

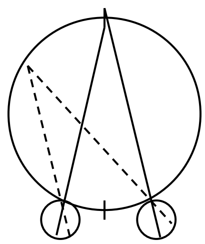


Figure 2

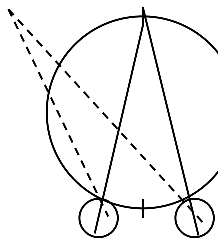


Figure 3

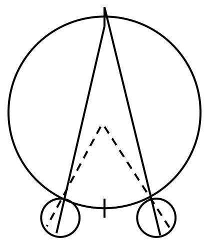
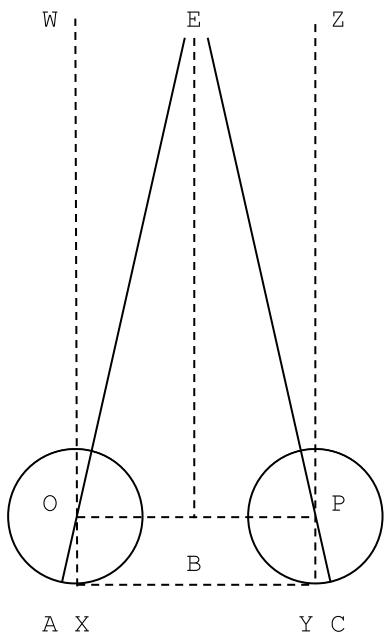


Figure 4
Two eyes can measure relative distance to a point by retinal disparity.



Two eyes have a distance between them (XY = OB + BP = 2 * OB).
eye radius = OX = OA = PY = PC
Point E is EB from the line between the eyes and OE (= PE) from the center of each eye and AE (= CE) from the retina of each eye.
When the eyes look straight ahead, the angle of convergence is zero.
In the left eye, point A is outside the fovea (X).
In the right eye, point C is outside the fovea (Y).

The same point in space projects to different positions on the two retinas (retinal disparity). The retina can measure the difference in positions and find the relative distances AX and CY.
AX/OX = angle AOX = angle EOW = angle OEB
OE/XY = (sin(pi/2 - angle OEB))/(sin(2*angle OEB))
OE/XY = (sin(pi/2 - AX/OX))/(sin(2*AX/OX))

From the relative angle, one can calculate distance relative to eye radius and eye separation.

1>Consciousness>Sense>Vision>Physiology>Motion>Parallax motion parallax

1/Consciousness/Sense/Vision/Physiology/Motion/Parallax/motion parallax.html

Figure 1

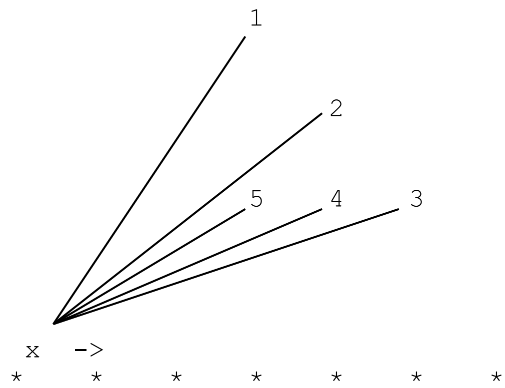


Figure 2

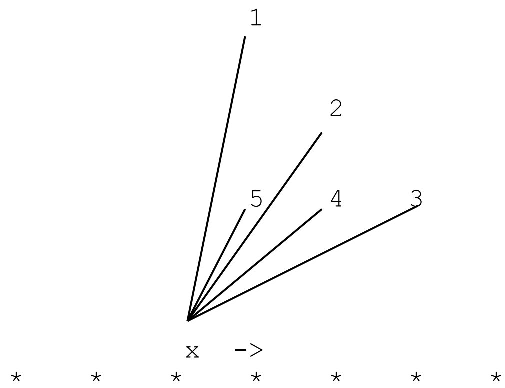
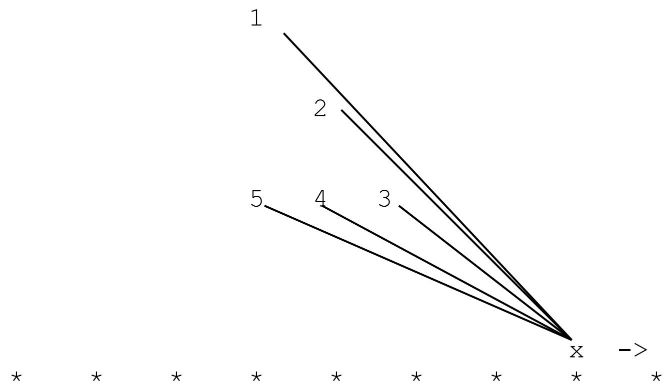


Figure 3



1>Consciousness>Sense>Vision>Color Vision
color frequency

1/Consciousness/Sense/Vision/Color Vision/color frequency.html

Figure 1

Color Wavelengths (and Extrapolated Wavelengths)

```
350     400     450     500     550     600     650     700     750
|   x   |   x   |   x   |   x   |   x   |   x   |   x   |   x   |

365 magenta (1 red : 1 blue)
     rose (5 blue : 4 red)
      purple (4 blue : 3 red)
       red-violet (3 blue : 2 red)
        408 violet (2 blue : 1 red)
           435 indigo (3 blue : 1 red)
               463 blue
                  cerulean (3 blue : 1 green)
                    turquoise (2 blue : 1 green)
                      500 cyan (1 blue : 1 green) or aqua blue
                        aqua green (1 blue : 2 green)
                           blue-green (1 blue : 3 green)
*                            543 green (1 blue : 1 yellow)
*                             spring green (3 green : 1 yellow)
                               yellow-green (2 green : 1 yellow)
                                560 chartreuse (1 yellow : 1 green)
                                   583 yellow (1 red : 1 green)
                                     golden-yellow (4 yellow : 1 red)
                                      orange-yellow (3 yellow : 1 red)
                                       yellow-orange (2 yellow : 1 red)
                                        608 orange (1 red : 1 yellow)
                                            vermilion (2 red : 1 yellow)
                                                scarlet (3 red : 1 yellow)
                                                   683 red
                                                     crimson(2 red : 1 blue)
*                                                       730 magenta
```

Figure 2

Example: How the Four Major Colors Make the Range of Colors

magenta	1/2 red	+ 1/2 blue
violet	1/3 red	+ 2/3 blue
indigo	1/4 red	+ 3/4 blue
blue		
turquoise	2/3 blue	+ 1/3 green
cyan	1/2 blue	+ 1/2 green
spring green	1/3 blue	+ 2/3 green
spring green	2/3 blue	+ 1/3 yellow
green		
green	1/2 yellow	+ 1/2 blue
chartreuse	2/3 yellow	+ 1/3 blue
chartreuse	1/2 yellow	+ 1/2 green
chartreuse	1/3 red	+ 2/3 green
yellow		
yellow	1/2 red	+ 1/2 green
orange	2/3 red	+ 1/3 green
orange	1/2 red	+ 1/2 yellow
red		
crimson	3/4 red	+ 1/4 blue
strawberry	2/3 red	+ 1/2 blue
magenta	1/2 red	+ 1/2 blue

Example: How the Three Additive Colors Make the Range of Colors

magenta	1/2 red	+ 1/2 blue
violet	1/3 red	+ 2/3 blue
indigo	1/4 red	+ 3/4 blue
blue		
turquoise	2/3 blue	+ 1/3 green
cyan	1/2 blue	+ 1/2 green
spring green	1/3 blue	+ 2/3 green
green		
chartreuse	1/3 red	+ 2/3 green
yellow	1/2 red	+ 1/2 green
orange	2/3 red	+ 1/3 green
red		
crimson	3/4 red	+ 1/4 blue
strawberry	2/3 red	+ 1/2 blue
magenta	1/2 red	+ 1/2 blue

Example: How the Three Subtractive Colors Make the Range of Colors

magenta		
blue	1/2 magenta	+ 1/2 cyan
cyan		
green	1/2 cyan	+ 1/2 yellow
yellow		
red	1/2 yellow	+ 1/2 magenta
magenta		

1>Consciousness>Sense>Vision>Color Vision
opponency

1/Consciousness/Sense/Vision/Color Vision/opponency.html

Figure 1

Example: Color vs. Cone Activity

Color		**Maximum-Sensitivity Wavelength for Receptors** Short 424	Medium 530	Long 560
blue		max	min	min
green		half	max	<max
yellow		min	half	<max
red			<half	half
white	(1 blue : 1 green : 1 red)	half	half	half
blue-white	(4 blue : 1 green : 1 red)	<max	>min	>min
green-white	(1 blue : 4 green : 1 red)	>half	<max	>half
yellow-white	(2 blue : 5 green : 5 red)	<half	>half	>half
red-white	(1 blue : 1 green : 4 red)	>min	half	>half

Example: Color vs. Opponent-Process Activity

Color	**Maximum**	**Range**	**L + M**	**L - M**	**L + M - S**
blue	(430 nm;	410 nm to 450 nm)			min
green	(530 nm;	490 nm to 560 nm)	<max	min	
green	(540 nm;	520 nm to 560 nm)	<max		max
yellow	(580 nm;	570 nm to 590 nm)	<max	half	
red	(610 nm;	590 nm to 630 nm)	half	max	
white	(560 nm;	500 nm to 650 nm)	max	half	half
blue-white	(4 blue : 1 green : 1 red)		half	min	>min
green-white	(1 blue : 4 green : 1 red)		max	<half	<max
yellow-white	(2 blue : 5 green : 5 red)		max	<<half	half
red-white	(1 blue : 1 green : 4 red)		<max	<half	<half

M - L gives same sequence as L - M.
M - S and L - S give same sequence as L + M - S.
S - M and S - L give same sequence as M - S and L - S.
S - (L + M) gives same sequence as L + M - S.
L - M - S and M - L - S have same information as L + M - S.
S - M + L and S - L + M have same information as L + M - S.

Adding L - M and L + M - S give same sequence as L + M - S.
Therefore, L - M and L + M - S cannot combine into one measurement, but are two independent parameters.

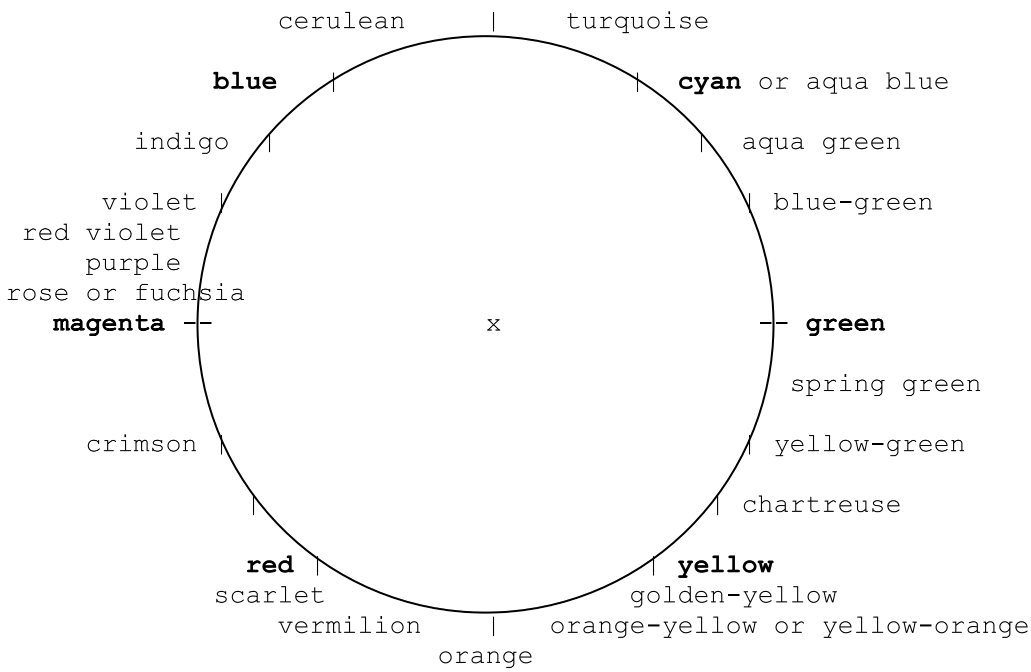
Unsaturation decreases L - M and increases L + M - S.

1>Consciousness>Sense>Vision>Color Vision>Color Wheel
color wheel

1/Consciousness/Sense/Vision/Color Vision/Color Wheel/color wheel.html

Figure 1

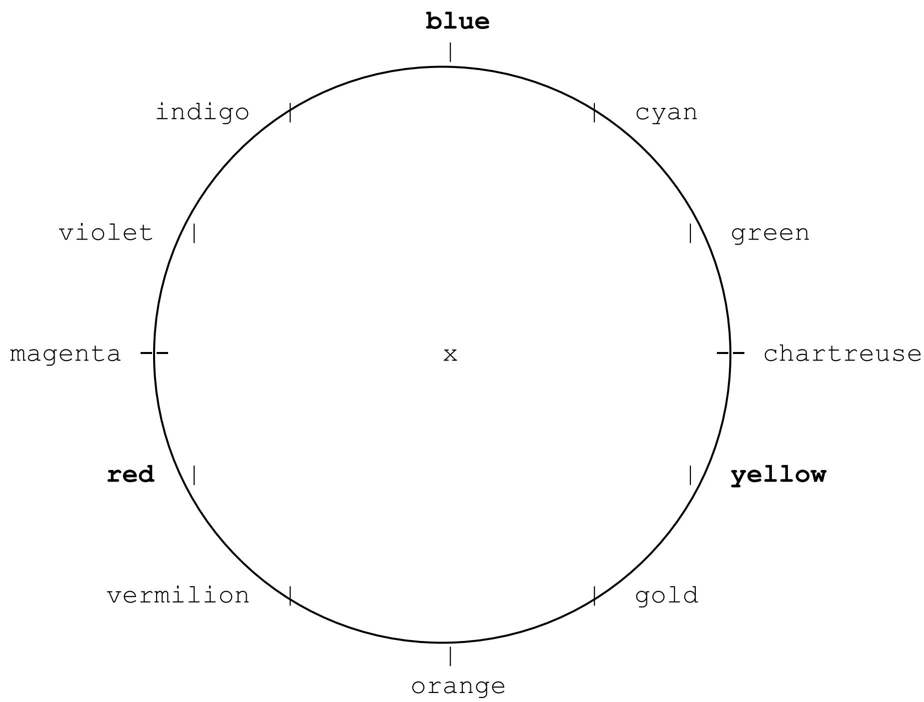
**Additive Colors in a Circle with Complementary Colors Opposite,
Red, Green, and Blue (and Yellow, Cyan, and Magenta) 120 degrees apart,
and Red, Green, and Blue 60 Degrees from Yellow, Cyan, and Magenta**



Complementary color lights make white.

Figure 2

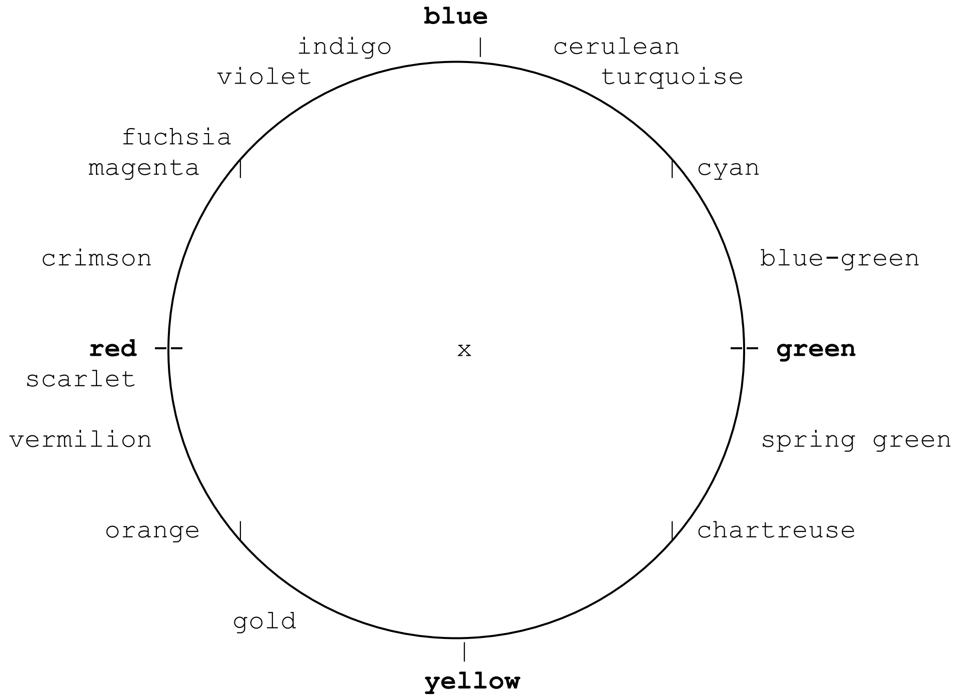
Example: Subtractive Colors in a Circle with Complementary Colors Opposite



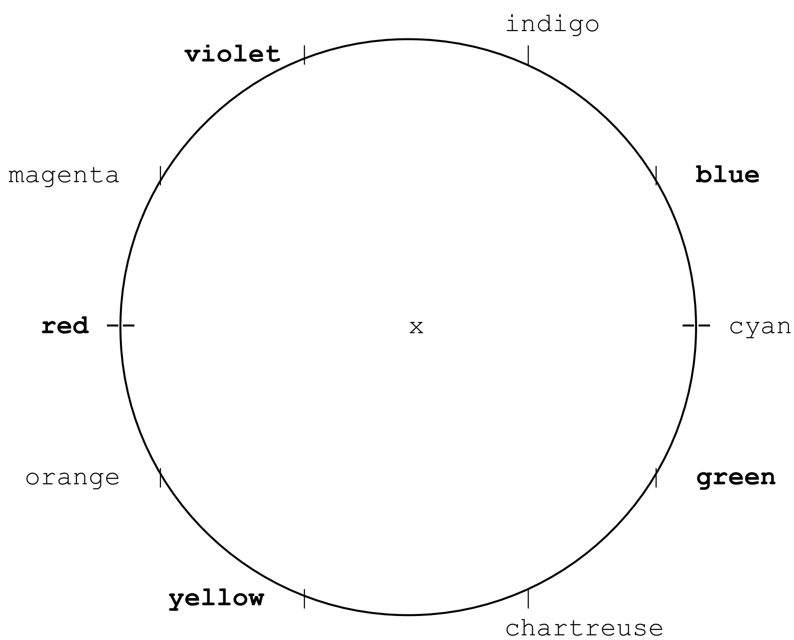
Complementary color pigments make black.

Figure 3

Example: Four Main Colors in a Square



Example: Colors in a Pentagram with Complementary Colors Opposite



1>Consciousness>Sense>Vision>Color Vision>Mixing Colors color mixture

1/Consciousness/Sense/Vision/Color Vision/Mixing Colors/color mixture.html

Figure 1

Example: How the Four Major Colors Make the Range of Colors

magenta	1/2 red + 1/2 blue
violet	1/3 red + 2/3 blue
indigo	1/4 red + 3/4 blue
blue	
turquoise	2/3 blue + 1/3 green
cyan	1/2 blue + 1/2 green
spring green	1/3 blue + 2/3 green
spring green	2/3 blue + 1/3 yellow
green	
green	1/2 yellow + 1/2 blue
chartreuse	2/3 yellow + 1/3 blue
chartreuse	1/2 yellow + 1/2 green
chartreuse	1/3 red + 2/3 green
yellow	
yellow	1/2 red + 1/2 green
orange	2/3 red + 1/3 green
orange	1/2 red + 1/2 yellow
red	
crimson	3/4 red + 1/4 blue
strawberry	2/3 red + 1/2 blue
magenta	1/2 red + 1/2 blue

Example: How the Three Additive Colors Make the Range of Colors

magenta	1/2 red + 1/2 blue
violet	1/3 red + 2/3 blue
indigo	1/4 red + 3/4 blue
blue	
turquoise	2/3 blue + 1/3 green
cyan	1/2 blue + 1/2 green
spring green	1/3 blue + 2/3 green
green	
chartreuse	1/3 red + 2/3 green
yellow	1/2 red + 1/2 green
orange	2/3 red + 1/3 green
red	
crimson	3/4 red + 1/4 blue
strawberry	2/3 red + 1/2 blue
magenta	1/2 red + 1/2 blue

Example: How the Three Subtractive Colors Make the Range of Colors

magenta	
blue	1/2 magenta + 1/2 cyan
cyan	
green	1/2 cyan + 1/2 yellow
yellow	
red	1/2 yellow + 1/2 magenta
magenta	

1>Consciousness>Sense>Vision>Illusions
illusion

1/Consciousness/Sense/Vision/Illusions/illusion.html

Figure 1
illusory contour

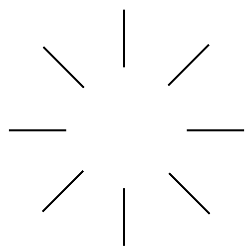


Figure 2
illusory contour

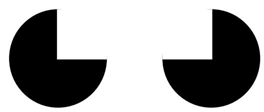


Figure 3
Necker cube

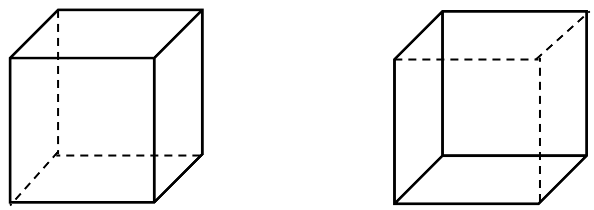


Figure 4
Hering illusion

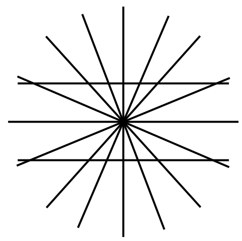


Figure 5
Rubin vase

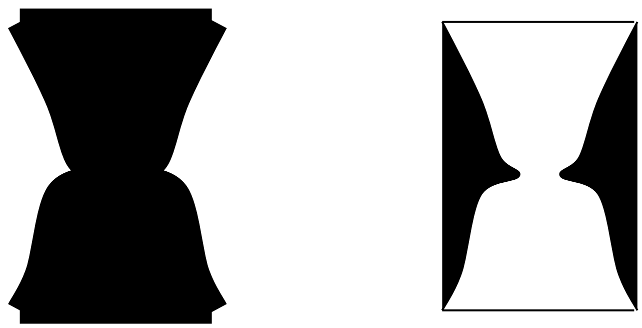


Figure 6
Zollner illusion

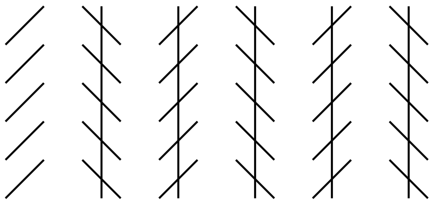


Figure 7
Ponzo illusion

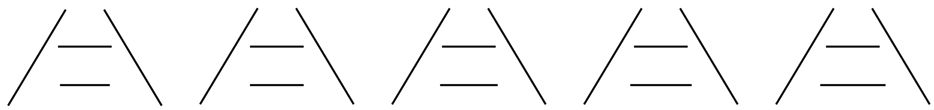


Figure 8
Modified Ponzo illusions

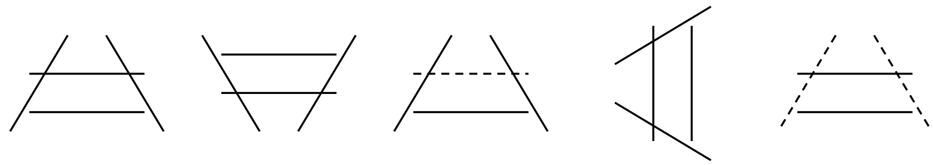
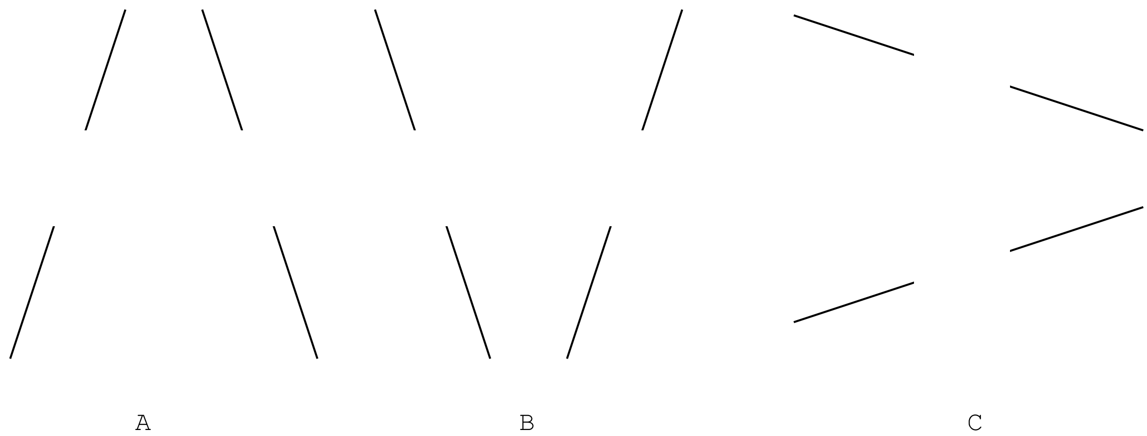


Figure 9
Split Ponzo illusions



A: Bottom lines appear to go up outside of upper lines, though the lines are the same.

B: Bottom lines appear to go up inside of upper lines, though the lines are the same.

C: Lines appear to be the same.

1>Consciousness>Speculations>Sensation>Biology>Brain color processing

1/Consciousness/Speculations/Sensation/Biology/Brain/color processing.html

Figure 1

```
                   Color Wavelengths (in nanometers)
350       400       450       500       550       600       650       700
|----*----|----S----|----*----|----*M---|-L--*----|----*----|----*----|----*
MMMMMMVVVVVVVVVIIIIBBBBBBCCCCCCCCCGGGGGGGCCCYYYYOOOOOORRRRRRRRRRRRRRRRRRRRMM
  M         V    I    B       C       G   C   Y     O             R        M
           410  435  460     500 520 540 560 580   610           680

     |  B     l     u     e   |  G  r  e  e  n  |  R       e       d      |

      Receptor Maximum-Sensitivity Wavelengths (in nanometers)
              424                  530   560
     380       S                      540
               430                  M                        660
               430                        L                             720
```

Color wavelengths range from 380 nm to 720 nm: Magenta, Violet, Indigo, Blue, Cyan, Green, Chartreuse, Yellow, Orange, and Red. Wavelengths under color letters indicate center of color range.
Blues predominate from 380 nm to 500 nm.
Blue-greens are from 460 nm to 545 nm.
Greens predominate from 500 nm to 590 nm.
Green-reds are from 545 nm to 630 nm.
Reds predominate from 590 nm to 720 nm.
Red-blues are from 630 nm to 460 nm.

S, M, and L are the short-wavelength, middle-wavelength, and long-wavelength photoreceptors. Photoreceptor spectral curves approximate a normal distribution, with maximum sensitivity at 424 nm, 530 nm, and 560 nm, respectively.
Short-wavelength range is 380 nm to 540 nm.
Middle-wavelength range is 430 nm to 660 nm.
Long-wavelength range is   430 nm to 720 nm.

Figure 2

Example: Color vs. Cone Activity

	Maximum-Sensitivity Wavelength for Receptors		
	Short	**Medium**	**Long**
Color	**424**	**530**	**560**
358	0	0	0
392	6	1	0
426	10	3	1
460 blue	9	7	4
494	7	9	7
528 green	2	10	9
562 green	1	9	10
596	0	7	9
630 red	0	4	7
664 red	0	1	4
698 red	0	0	1
732	0	0	0

Example: Color vs. Color-Opponent Activity

	540(green)	**501(cyan)**			
Color	**L - M**	**L + M - S**	**L + M**	**-1 to +1**	**-1, 0, +1**
358*magenta	0	0	0		(+1,-1)
392 violet	-1	-5	1		(0,-1)
426 indigo	-2	-6	4		(-1,-1)
460 blue	-3	2	11	(-1,-1)	(-1, 0)
494 cyan	-2	9	16		(-1,+1)
528 green	-1	17	19	(0, 0)	(0,+1)
562 green	1	18	19		(0,+1)
596 yellow	2	16	16		(+1,+1)
630 orange	3	11	11		(+1,+1)
664 red	3	5	5	(+1,+1)	(+1, 0)
698 crimson	1	1	1		(0, 0)
732*magenta	0	0	0		(+1,-1)

L-M	**L+M-S** -1	0	+1
-1	indigo	blue	cyan
0	violet	crimson	green
+1	magenta	red	yellow

Threshold for	**L - M**	**(L + M) - S**
red (not from blue to green)	+1 > x > 0	+1 > y > 0
green (not from red to blue)	-1 < x < 1	-1 < y < +1
blue (not from red to green)	-1 < x < 0	-1 < y < 0

Cone pairs are symmetric around their mean, and so color pairs are just opposites, with no phenomenal color.

A cone triple makes colors asymmetric and so able to have different perceptual colors.

Figure 3

Example: Color vs. Cone Activity

		Maximum-Sensitivity Wavelength for Receptors		
		Short	**Medium**	**Long**
Color		**424**	**530**	**560**
crimson	(.75 red + .25 blue)	2	1	3
magenta	(.50 red + .50 blue)	4	0	2
violet	(.25 red + .75 blue)	6	1	1
blue	(1 blue)	6	2	0
turquoise	(.75 blue + .25 green)	5	3	1
cyan	(.50 blue + .50 green)	4	4	2
spring	(.25 blue + .75 green)	3	5	3
green	(1 green)	2	6	4
chartreuse	(.25 red + .75 green)	1	5	5
yellow	(.50 red + .50 green)	0	4	6
orange	(.75 red + .25 green)	0	3	5
red	(1 red)	0	2	4

Example: Color vs. Color-Opponent Activity

Color		**L-M**	**L+M-S**	**L+M**	**M-L+L+M**	**Combined**
crimson (1)		2	0	2	0	2
magenta (2)		1	-1	1	0	2
violet (3)		0	-2	0	0	2
blue (4)		-1	-3	1	2	2
turquoise (5)		-2	-2	2	4	2
cyan (6)	(.75 blue + .25 yellow)	-3	-1	3	6	2
spring (1)		-2	0	4	6	2
green (2)	(.5 blue + .5 yellow)	-1	1	5	6	2
chartreuse (3)	(.5 yellow + .5 green)	0	2	6	6	2
yellow (4)		1	3	5	4	2
orange (5)	(.5 red + .5 yellow)	2	2	4	2	2
red (6)		3	1	3	0	2

Numbers in parentheses show complementary colors.
L-M has maximum at red and minimum at cyan.
L+M has maximum at chartreuse and minimum at violet.
M-L and L+M have maximum at green and minimum at magenta.
L+M-S has maximum at yellow and minimum at blue.

Opponencies make color categories: blue, green, yellow, and red.
Other colors mix these colors.

S-L-M and L-M and (L-M and L+M) have no maxima or minima.

Combining opponencies makes white, because red, green, and blue mix equally.
Combining opponencies makes black, because cyan, magenta, and yellow mix equally. Grays mix black and white.

1>Consciousness>Speculations>Sensation>Mathematics>Color
harmonic ratios and color

1/Consciousness/Speculations/Sensation/Mathematics/Color/harmonic ratios and color.html

Figure 1

Color Wavelength Ratios

	/red	/ora	/yel	/cha	/gre	/cya	/blu	/ind	/vio	/mag
730 magenta										2
683 red/	1	**1.12**	**1.17**	1.22	**1.26**	1.37	**1.48**	1.57	**1.67**	**1.87**
608 orange/		1	1.04	1.09	**1.12**	1.22	**1.31**	1.40	**1.49**	**1.67**
583 yellow/			1	1.04	1.07	1.17	**1.26**	1.34	**1.43**	**1.60**
560 chartreuse/				1	1.03	1.12	1.21	1.29	1.37	1.53
543 green/					1	1.09	**1.17**	**1.25**	**1.33**	**1.49**
500 cyan						1	1.08	1.15	1.23	1.37
463 blue/							1	1.06	**1.13**	**1.27**
435 indigo/								1	1.07	1.20
408 violet/									1	1.12
365 magenta										1

Colors and Frequency Ratios

Color	**Ratio**	**Color Tone**	
magenta	0.94 = 15/16	B	
red	1.00 = 1/1	C	= 2^0.00
orange	1.12 = 9/8	D	= 2^0.17
yellow	1.20 = 6/5	D#	= 2^0.25
green	1.25 = 5/4	E	= 2^0.33
cyan	1.33 = 4/3	F	= 2^0.42
blue	1.50 = 3/2	G	= 2^0.58
violet	1.67 = 5/3	A	= 2^0.75
magenta	1.88 = 15/8	B	= 2^0.92

Figure 2

Colors distribute approximately equally by wavelength across the visible spectrum.

Color	Wavelength (nm)	Difference (nm)
Magenta		
Violet	410	40
Blue	460	50
Cyan	500	40
Green	540	40
Yellow	580	40
Orange	610	30
Red	650	40
Magenta		40
		320

Colors distribute approximately equally around green, by wavelength.

Color	Wavelength (nm)	Difference (nm)
Magenta	380	-160
Violet	410	-130
Blue	460	-80
Cyan	500	-40
Green	540	0
Yellow	580	+40
Orange	610	+70
Red	660	+120
Magenta	700	+160

Equal-wavelength separations make a series of small-integer (harmonic) ratios.

Color	Multiples	Ratios
Magenta	0	0
Violet	40	1
Blue	80	2
Cyan	120	3
Green	160	4
Yellow	200	5
Orange	240	6
Red	280	7
Magenta	320	8

Figure 3

Fit into an octave, color wavelengths have small-integer (harmonic) ratios.

Color	Tone	Logarithm	Ratio	Numeric Ratio
Magenta	C	2^0.00	1/1	1.00
Violet	C#	2^0.06	13/12	1.09
Indigo	D	2^0.13	9/8 or 8/7	1.13 or 1.14
Blue	D#	2^0.19	7/6	1.17
Turquoise	E	2^0.25	6/5	1.20
Turquoise	E	2^0.32	5/4	1.25
Cyan	F	2^0.38	4/3	1.33
Spring	F	2^0.44	11/8	1.38
Green	F#	2^0.50	17/12	1.42
Chartreuse	G	2^0.56	3/2	1.50
Chartreuse	G	2^0.63	19/12	1.58
Yellow	A	2^0.69	13/8	1.63
Orange	A	2^0.75	5/3	1.67
Vermilion	A#	2^0.82	7/4	1.75
Red	B	2^0.88	11/6	1.83
Crimson	B	2^0.94	23/12 or 15/8	1.92
Magenta	C	2^1.00	2/1	2.00

1>Consciousness>Speculations>Sensation>Psychology>Sense>Vision color properties

1/Consciousness/Speculations/Sensation/Psychology/Sense/Vision/color properties.html

Figure 1

```
                   Color Wavelengths (in nanometers)
350       400       450       500       550       600       650       700
|----*----|----S----|----*----|----*M---|-L--*----|----*----|----*----|----*
MMMMMMVVVVVVVVVVIIIIBBBBBBBCCCCCCCCGGGGGGGCCCYYYYOOOOOORRRRRRRRRRRRRRRRRRRMM
  M         V    I    B       C       G   C   Y     O             R        M
           410  435  460      500 520 540 560 580   610            680

     |  B     l     u     e   |  G  r  e  e  n  |  R       e       d      |

      Receptor Maximum-Sensitivity Wavelengths (in nanometers)
              424                  530   560
     380       S                      540
               430                  M                        660
               430                        L                             720
```

Color wavelengths range from 380 nm to 720 nm: Magenta, Violet, Indigo, Blue, Cyan, Green, Chartreuse, Yellow, Orange, and Red. Wavelengths under color letters indicate center of color range.
Blues predominate from 380 nm to 500 nm.
Blue-greens are from 460 nm to 545 nm.
Greens predominate from 500 nm to 590 nm.
Green-reds are from 545 nm to 630 nm.
Reds predominate from 590 nm to 720 nm.
Red-blues are from 630 nm to 460 nm.

S, M, and L are the short-wavelength, middle-wavelength, and long-wavelength photoreceptors. Photoreceptor spectral curves approximate a normal distribution, with maximum sensitivity at 424 nm, 530 nm, and 560 nm, respectively.
Short-wavelength range is 380 nm to 540 nm.
Middle-wavelength range is 430 nm to 660 nm.
Long-wavelength range is   430 nm to 720 nm.

Figure 2

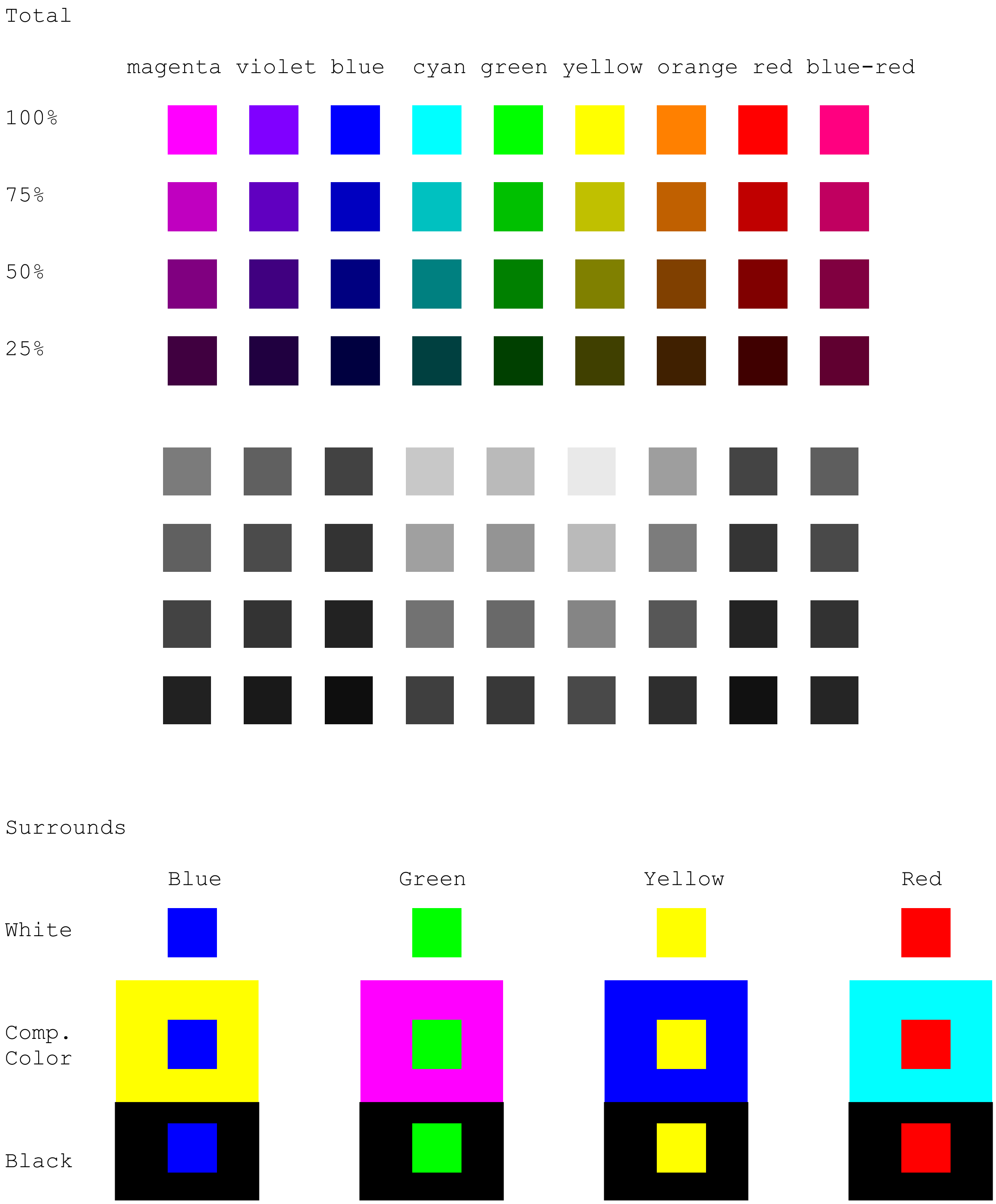

Total
magenta violet blue cyan green yellow orange red blue-red
100%
75%
50%
25%
Surrounds
Blue
Green
Yellow
Red
White
Comp. Color
Black

Figure 3

Saturation

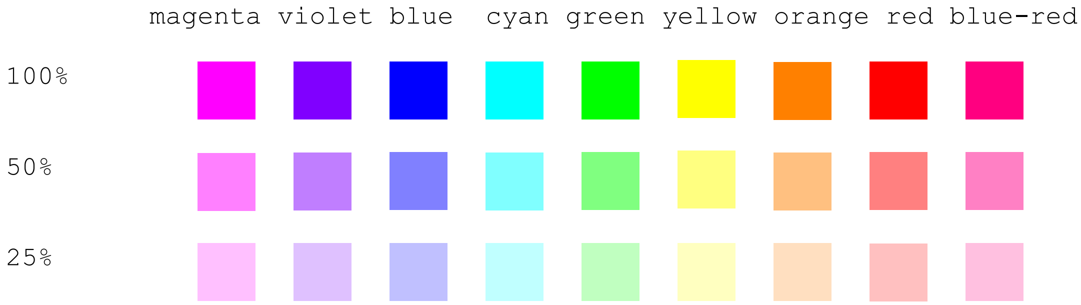


Figure 4

Transparency

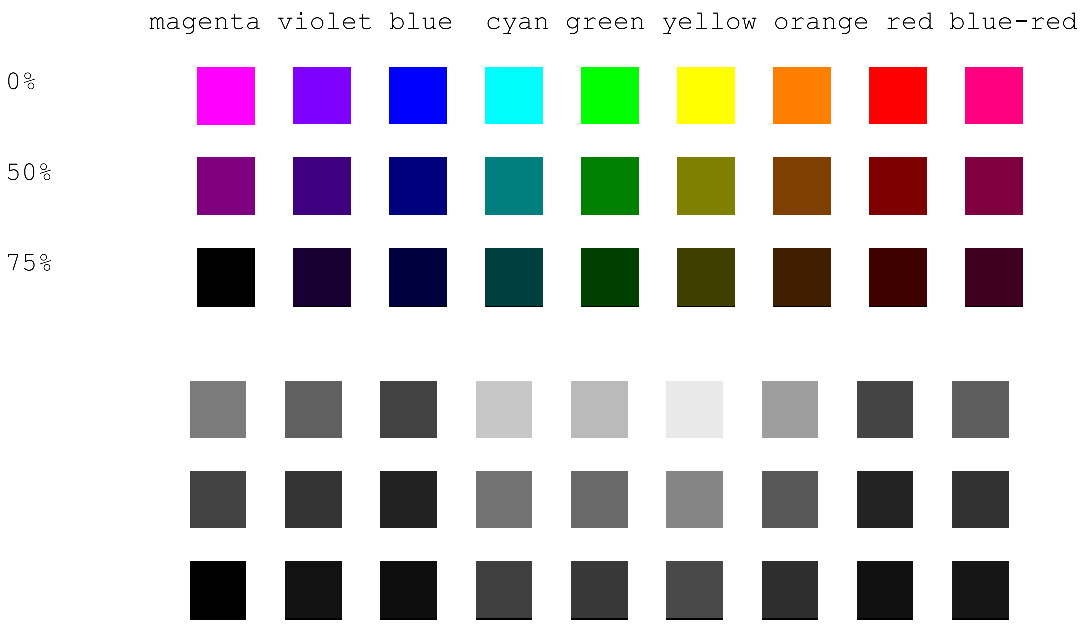


Figure 5

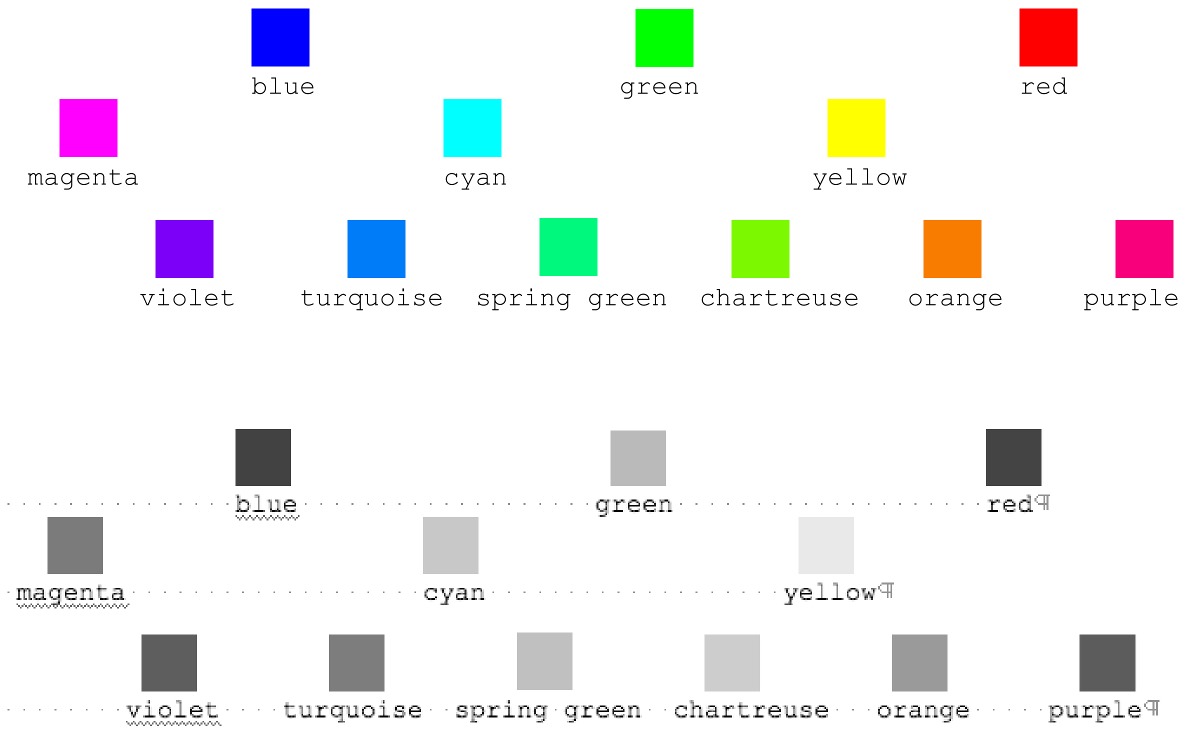
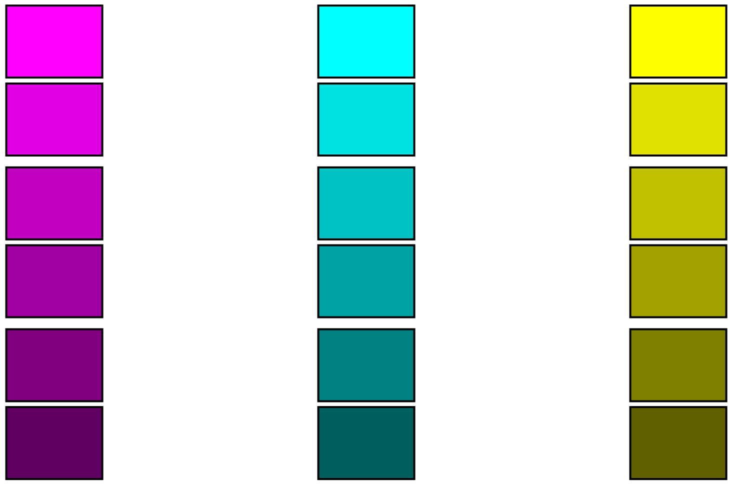
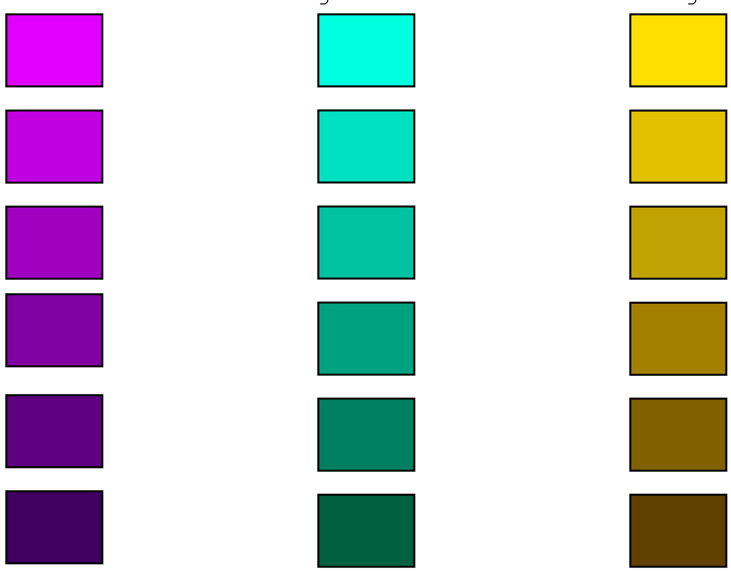

blue
green
red
magenta
cyan
yellow
violet
turquoise
spring green
chartreuse
orange
purple
blue
green
red
magenta
cyan
yellow
violet
turquoise
spring green
chartreuse
orange
purple

Figure 6

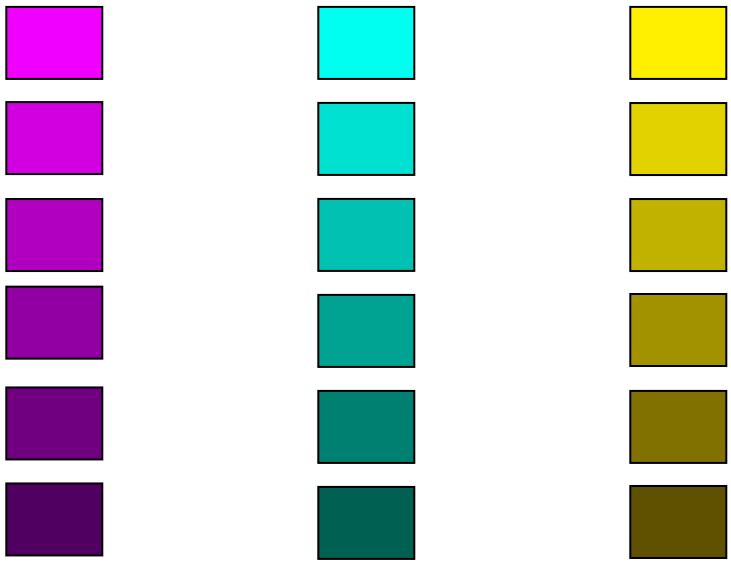
When both colors have equal amounts, as color decreases amount,
red > blue   blue > green   green > red



When stronger color is 32 bits lower, as color decreases amount,
weaker color can appear:
blue   green   orange



When stronger color is 16 bits lower, as color decreases amount,
colors balance:



1>Consciousness>Speculations>Sensation>Psychology>Sense>Vision
color facts

1/Consciousness/Speculations/Sensation/Psychology/Sense/Vision/color facts.html

Figure 1

By percent white:

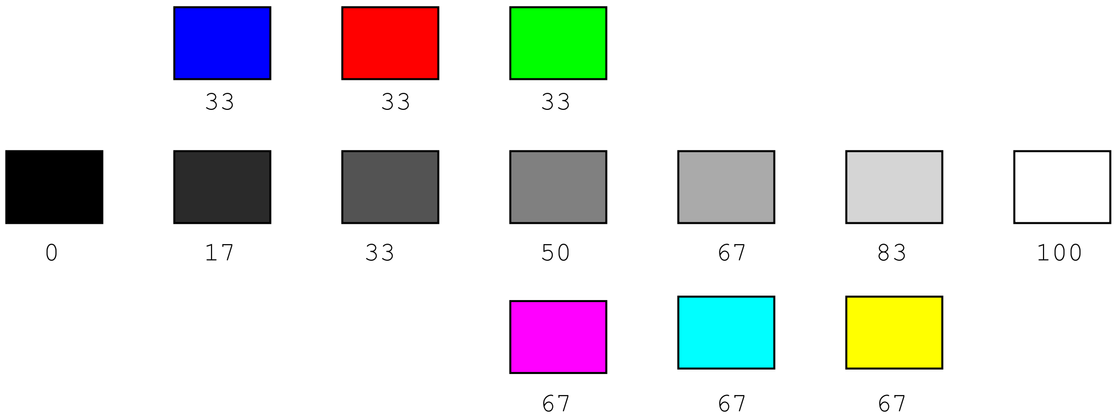
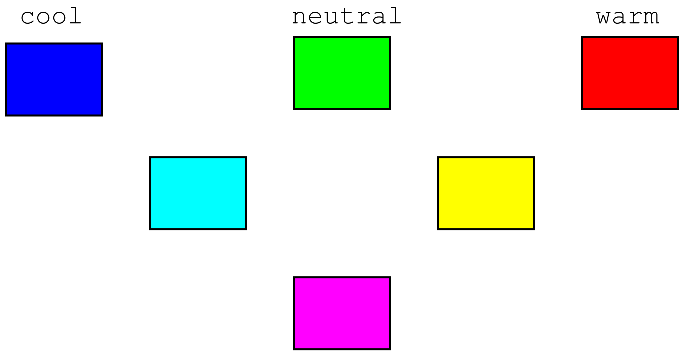


Figure 2



1>Consciousness>Speculations>Space layers and three-dimensional space

1/Consciousness/Speculations/Space/layers and three-dimensional space.html

Figure 1

Top	**Middle**	**Bottom**
010	000	000
111	010	010
010	000	000

Figure 2

Top/Mid/Bottom

```
Left/Mid/Right
 010/000/000
 111/010/010
 010/000/000
```

Figure 3

T11	M11	B11	**T12**	M12	B12	T13	M13	B13
T21	M21	B21	**T22**	**M22**	**B22**	**T23**	M23	B23
T31	M31	B31	**T32**	M32	B32	T33	M33	B33
0	0	0	**1**	0	0	0	0	0
1	0	0	**1**	**1**	**1**	**1**	0	0
0	0	0	**1**	0	0	0	0	0

where T = top, M = middle, and B = bottom
11 is top left, and 33 is bottom right,
and nonzero intensities are in bold.

1>Consciousness>Speculations>Sensation Space Observer
What Is Color

1/Consciousness/Speculations/Sensation Space Observer/What Is Color.html

Figure 1

Primary, Secondary, and Tertiary Hues

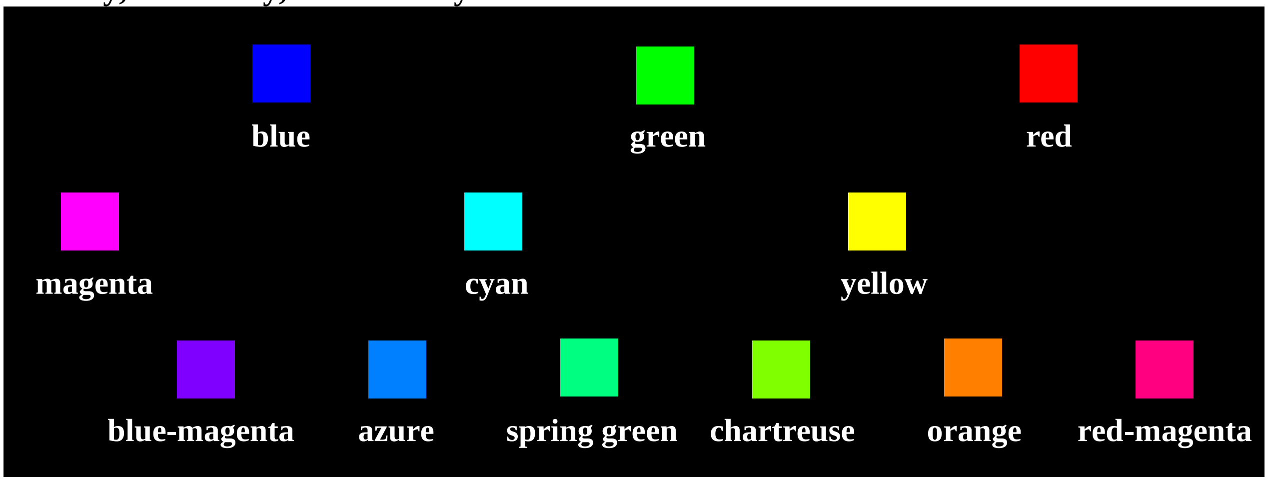


Figure 2

Color Lightness for RGB Primary, Secondary, and Tertiary Colors with White/Black/Gray

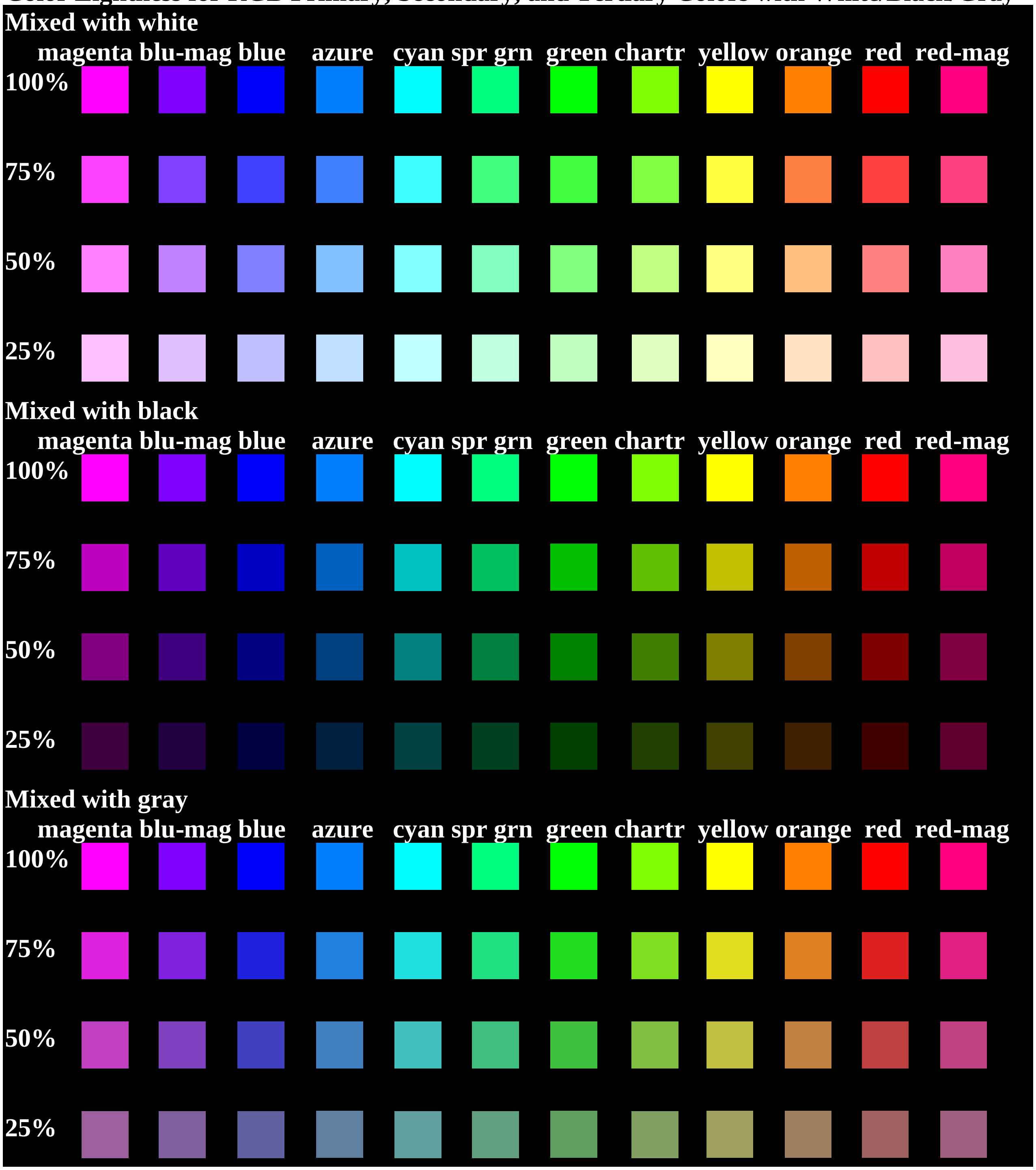


Figure 3

Gray Lightness in relation to White Percentage

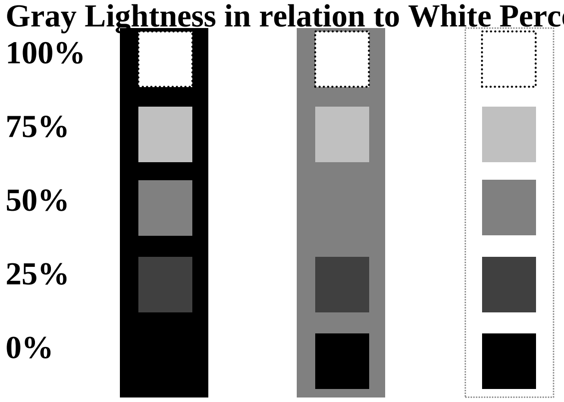


Figure 4

Primary-color and Yellow Lightness in White, Complementary Color, and Black

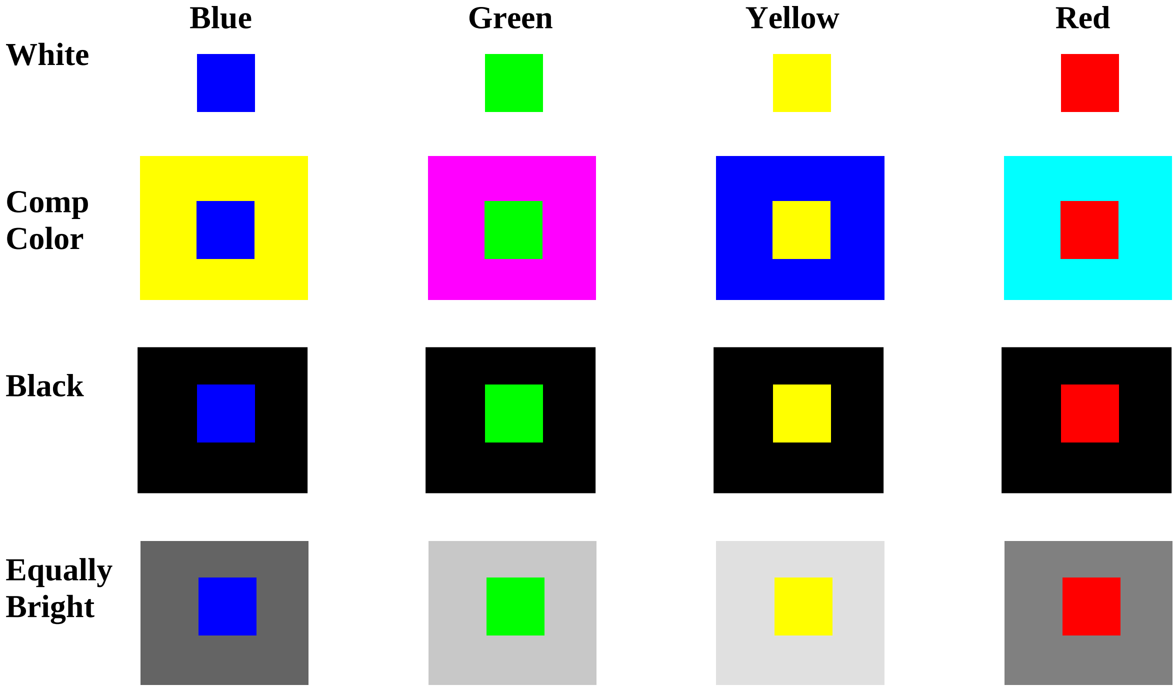


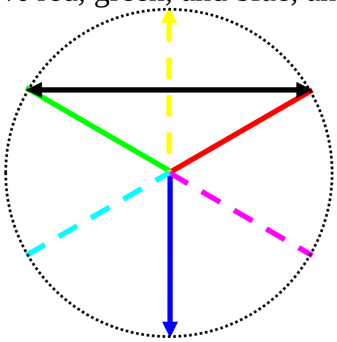
Figure 5

Primary Colors with both Black and White

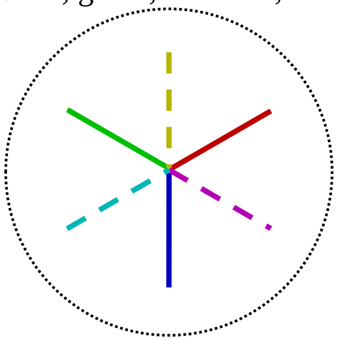
Figure 6

Three primary colors in a plane at 120-degree angles, and their equal-mixture colors

100% red, green, and blue, and 100% yellow, cyan, and magenta



75% red, green, and blue, and 75% yellow, cyan, and magenta



50% red, green, and blue, and 50% yellow, cyan, and magenta

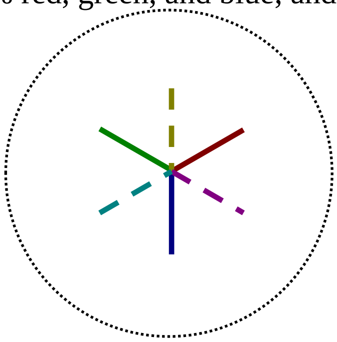


Figure 7

Stacking

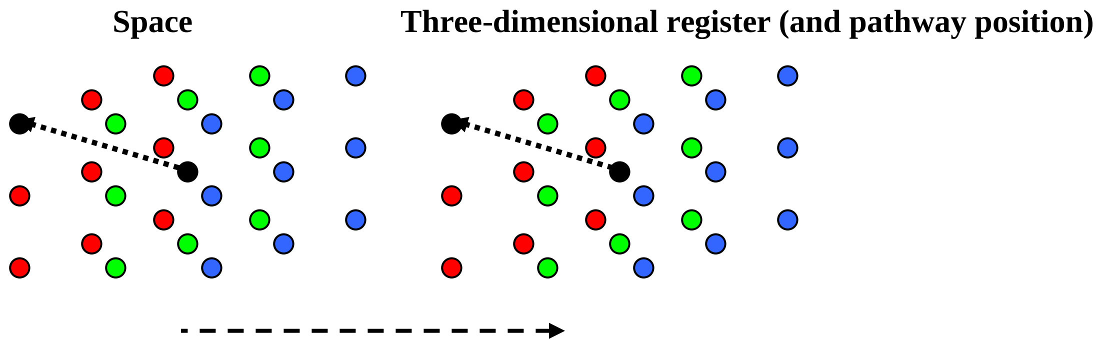


Figure 8
Skewing

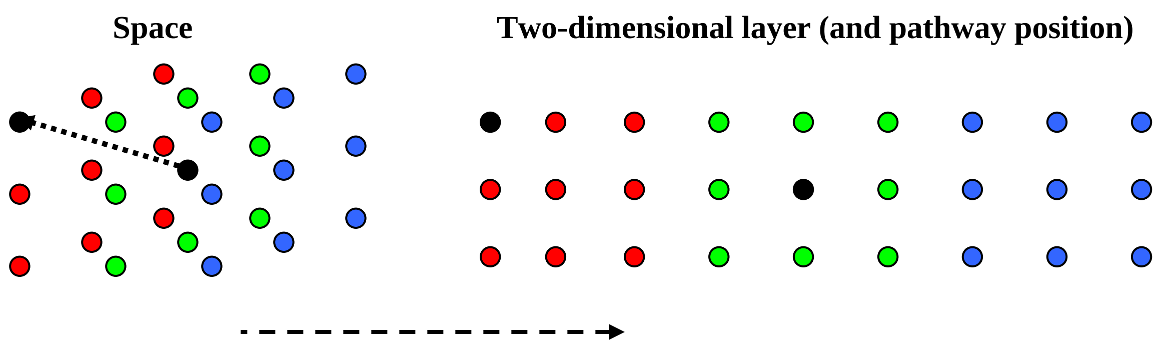


Figure 9

Interleafing

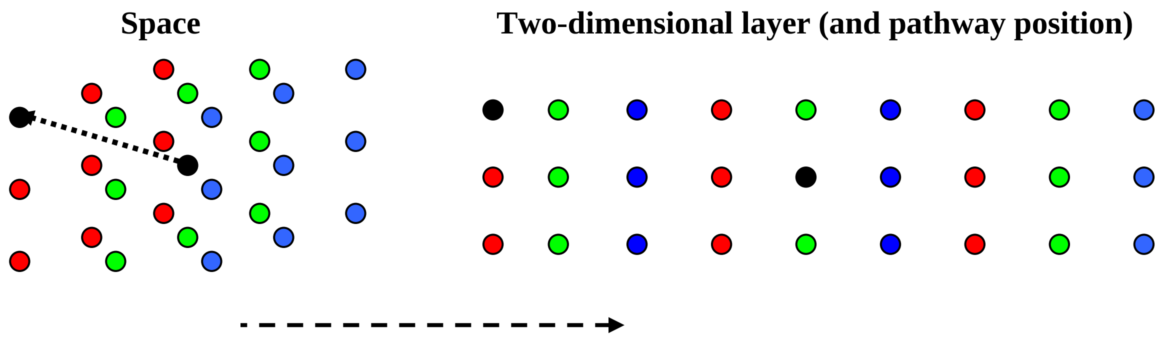


Figure 10

Planar graph for box

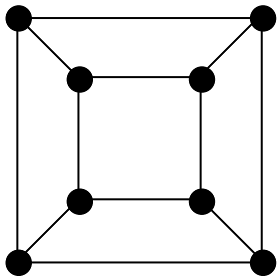


Figure 11

Dual graph of planar graph for box

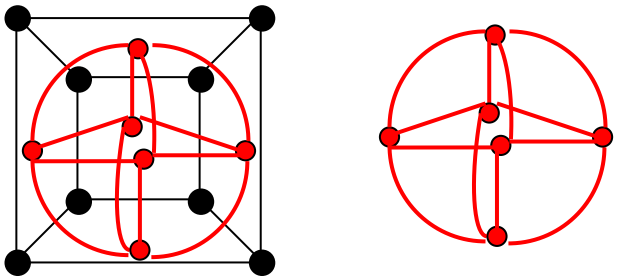
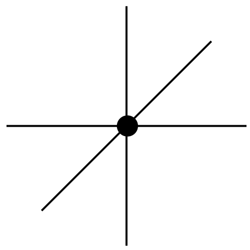


Figure 12

Line graph for box



2>Art>Painting>Linear Perspective
linear perspective

2/Art/Painting/Linear Perspective/linear perspective.html

Figure 1

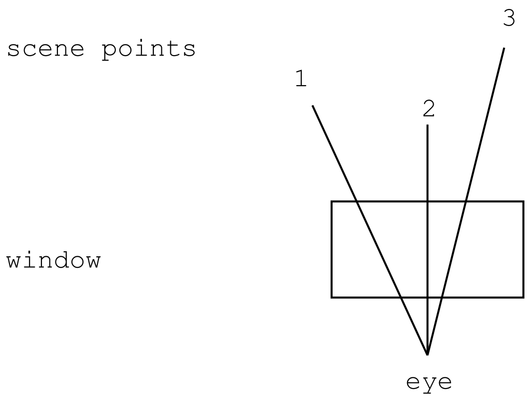


Figure 2

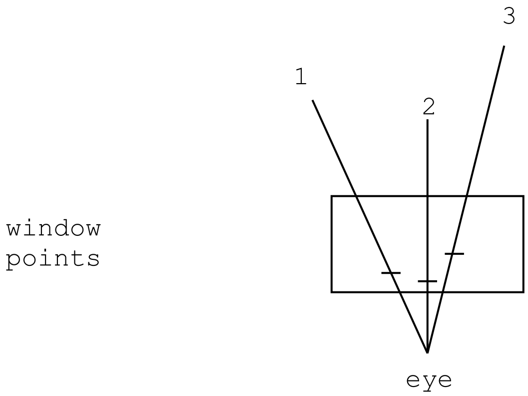


Figure 3

vertical
lines ->

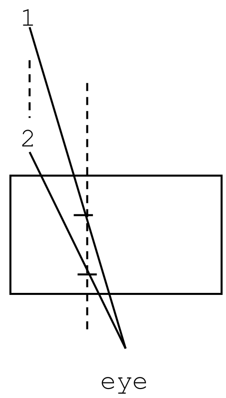


Figure 4

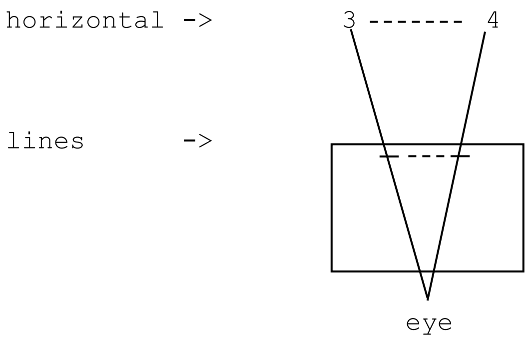
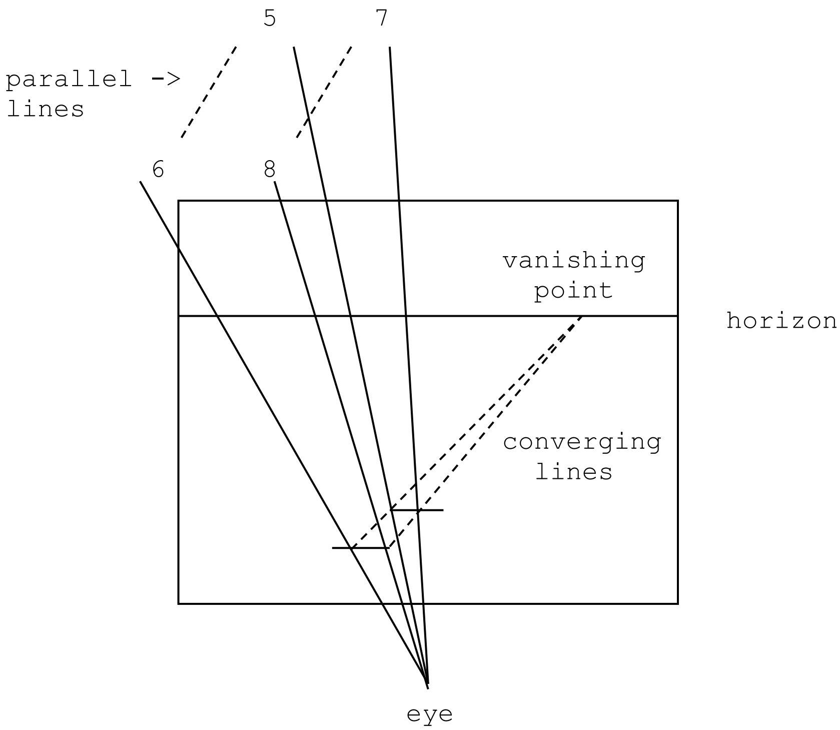


Figure 5


5
7
parallel ->
lines
6
8
vanishing
point
horizon
converging
lines
eye

3>Mathematics>Axiomatic Theory>Completeness Godel completeness theorem

3/Mathematics/Axiomatic Theory/Completeness/Godel completeness theorem.html

Figure 1

1	1	1	1	1	1	1	1	.	.	.
0	0	0	0	0	0	0	0	.	.	.
1	0	1	0	1	0	1	0	.	.	.
0	1	0	1	0	1	0	1	.	.	.
1	0	0	1	0	0	1	0	.	.	.
0	1	0	0	1	0	0	1	.	.	.
0	0	1	0	0	1	0	0	.	.	.
1	0	0	0	1	0	0	0	.	.	.
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.

Figure 2

1	1	1	1	1	1	1	1	.	.	.
0	**0**	0	0	0	0	0	0	.	.	.
1	0	**1**	0	1	0	1	0	.	.	.
0	1	0	**1**	0	1	0	1	.	.	.
1	0	0	1	**0**	0	1	0	.	.	.
0	1	0	0	1	**0**	0	1	.	.	.
0	0	1	0	0	1	**0**	0	.	.	.
1	0	0	0	1	0	0	**0**	.	.	.
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.

Figure 3

from Figure 2 diagonal
1 0 1 1 0 0 0 0 . . .

to new sequence by changing each position
0 1 0 0 1 1 1 1 . . .

3>Calculus>Differentiation
differentiation in calculus

3/Calculus/Differentiation/differentiation in calculus.html

Figure 1

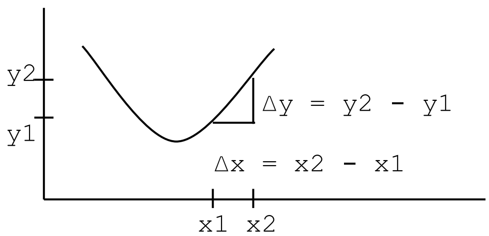
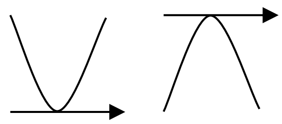


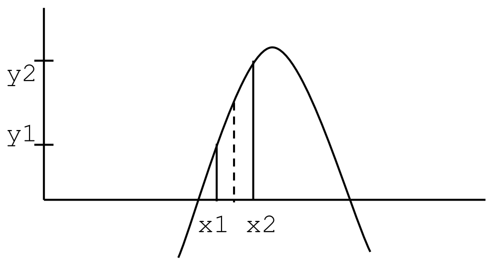
Figure 2



3>Calculus>Integration
integration in calculus

3/Calculus/Integration/integration in calculus.html

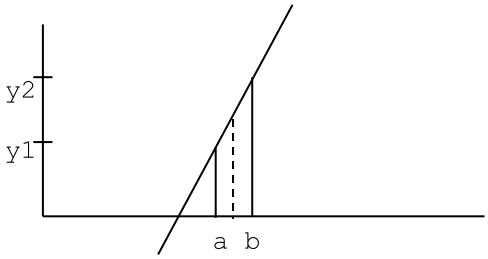
Figure 1



N = 2

Δx = (x2 - x1)/2

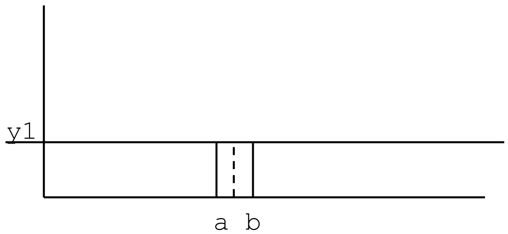
Figure 2



N = 2

$\Delta x = (x2 - x1)/2$

Figure 3



N = 2

$\Delta x = (x2 - x1)/2$

y = y1

3>Geometry>Plane>Polygon>Types>Triangle
Pythagorean theorem

3/Geometry/Plane/Polygon/Types/Triangle/Pythagorean theorem.html

Figure 1

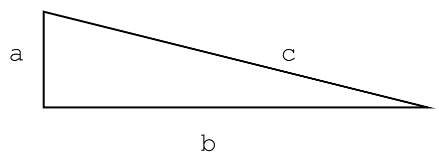


Figure 2

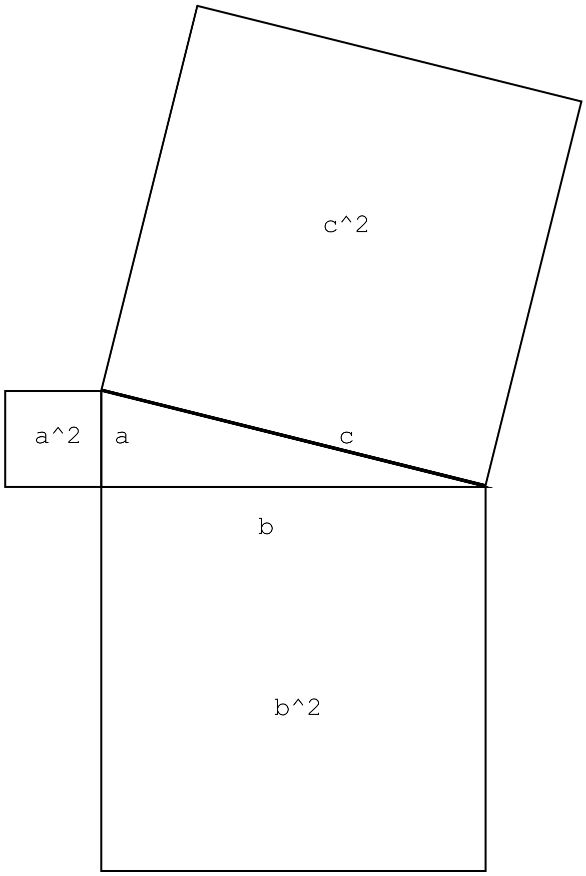


Figure 3

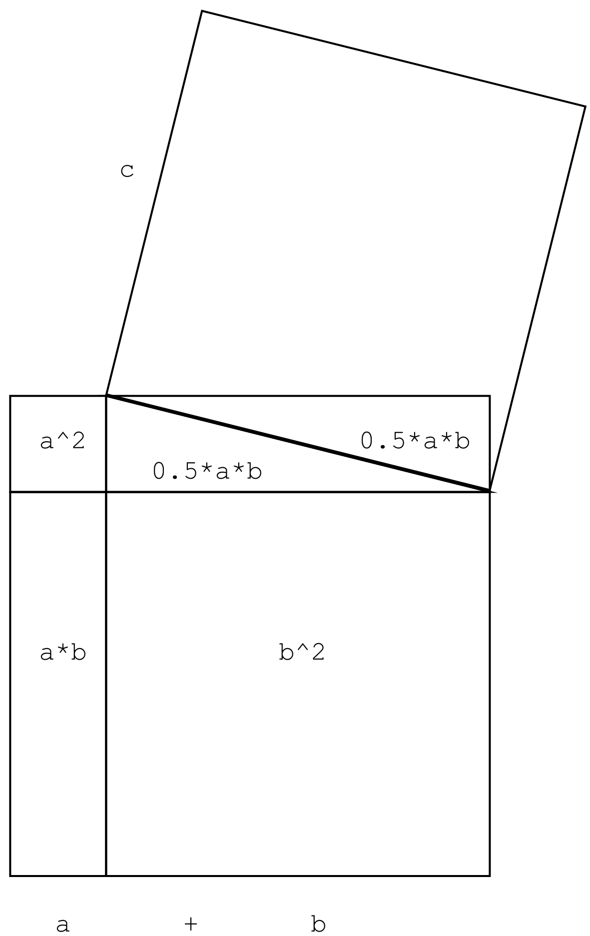
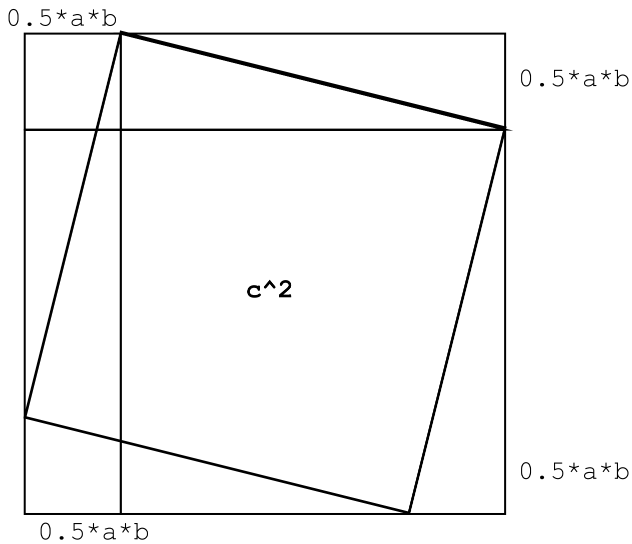


Figure 4



3>Number Theory
continuum in number theory

3/Number Theory/continuum in number theory.html

Figure 1

```
            Natural Numbers:  0   1   2   3   4   5   6  ...
                   Integers:  0  -1   1  -2   2  -3   3  ...
           Rational numbers: n0  n1  n2  n3  n4  n5  n6  ...
Countable Irrational Numbers: n0  n1  n2  n3  n4  n5  n6  ...
```

Figure 2

Natural number	Irrational number expressed in binary coding
0	1 1 1 1 1 1 1 1 . . .
1	0 0 0 0 0 0 0 0 . . .
2	1 0 1 0 1 0 1 0 . . .
3	0 1 0 1 0 1 0 1 . . .
4	1 0 0 1 0 0 1 0 . . .
5	0 1 0 0 1 0 0 1 . . .
6	0 0 1 0 0 1 0 0 . . .
7	1 0 0 0 1 0 0 0 . . .
.	. . . .
.	. . . .
.	. . . .

Figure 3

Natural number	Irrational number
0	**1** 1 1 1 1 1 1 1 . . .
1	0 **0** 0 0 0 0 0 0 . . .
2	1 0 **1** 0 1 0 1 0 . . .
3	0 1 0 **1** 0 1 0 1 . . .
4	1 0 0 1 **0** 0 1 0 . . .
5	0 1 0 0 1 **0** 0 1 . . .
6	0 0 1 0 0 1 **0** 0 . . .
7	1 0 0 0 1 0 0 **0** . . .
.	. . . .
.	. . . .
.	. . . .

Figure 4

from Figure 3 diagonal
1 0 1 1 0 0 0 0 . . .

to new sequence by changing each position
0 1 0 0 1 1 1 1 . . .

3>Computer Science>Software>Database
pivoting of data

3/Computer Science/Software/Database/pivoting of data.html

Figure 1

Persons	Days	D1	D2	D3
P1		L1	L2	L3
P2		L2	L3	L1
P3		L3	L1	L2

Figure 2

Locations	Days	D1	D2	D3
L1		P1	P3	P2
L2		P2	P1	P3
L3		P3	P2	P1

3>Computer Science>Systems
Turing machine

3/Computer Science/Systems/Turing machine.html

Figure 1

```
Tape:                ...0001000...
Tape Reader Position: | (starting position)
```

Figure 2

```
Tape:                 ...0001000...
Tape Reader Position:  |
```

Figure 3

```
Tape:                 ...0001000...
Tape Reader Position:    |
```

Figure 4

```
Tape:                  ...0001000...
Tape Reader Position:      |
```

Figure 5

```
Tape:                 ...0001000...
Tape Reader Position:      |
STOP.
```

3>Computer Science>Systems>Complexity Theory
halting problem

3/Computer Science/Systems/Complexity Theory/halting problem.html

Figure 1

Turing machine number	Input number: 0	1	2	3	4	5	6	7	.	.	.
0	1	1	1	1	1	1	1	1	.	.	.
1	0	0	0	0	0	0	0	0	.	.	.
2	1	0	1	0	1	0	1	0	.	.	.
3	0	1	0	1	0	1	0	1	.	.	.
4	1	0	0	1	0	0	1	0	.	.	.
5	0	1	0	0	1	0	0	1	.	.	.
6	0	0	1	0	0	1	0	0	.	.	.
7	1	0	0	0	1	0	0	0	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.

Figure 2

Turing machine number	Input number:	0	1	2	3	4	5	6	7	.	.	.
0		**1**	1	1	1	1	1	1	1	.	.	.
1		0	**0**	0	0	0	0	0	0	.	.	.
2		1	0	**1**	0	1	0	1	0	.	.	.
3		0	1	0	**1**	0	1	0	1	.	.	.
4		1	0	0	1	**0**	0	1	0	.	.	.
5		0	1	0	0	1	**0**	0	1	.	.	.
6		0	0	1	0	0	1	**0**	0	.	.	.
7		1	0	0	0	1	0	0	**0**	.	.	.
.		.	.	.	.	.	.	.	.	.	.	.
.		.	.	.	.	.	.	.	.	.	.	.
.		.	.	.	.	.	.	.	.	.	.	.

Figure 3

from Figure 2 diagonal
1 0 1 1 0 0 0 0 . . .

to new sequence by changing each position
0 1 0 0 1 1 1 1 . . .

4>Biology>Evolution>Theory
evolution theory

4/Biology/Evolution/Theory/evolution theory.html

Figure 1

This species has four members that are the same but vary in font style:

S1 **S2** *S3* S4

S1 reproduces exactly. **S2** changes an existing value. *S3* makes a new value. S4 makes a new quality:

S1 *S3* ***S5*** S4T1

A species requires a limited resource R1 to reproduce. A species produces more offspring than can reproduce. The members must compete for that resource:

S1 *S3* ***S5*** S4T1

R1

If the resource is reusable, only one species member can reproduce at a time. If the resource is usable only once, only one species member can reproduce. The best-adapted member will reproduce:

S1 *S3* ***S5***

R1-S4T1

That one species member will pass on its qualities and quality values, but the others will not:

R1-S4T1

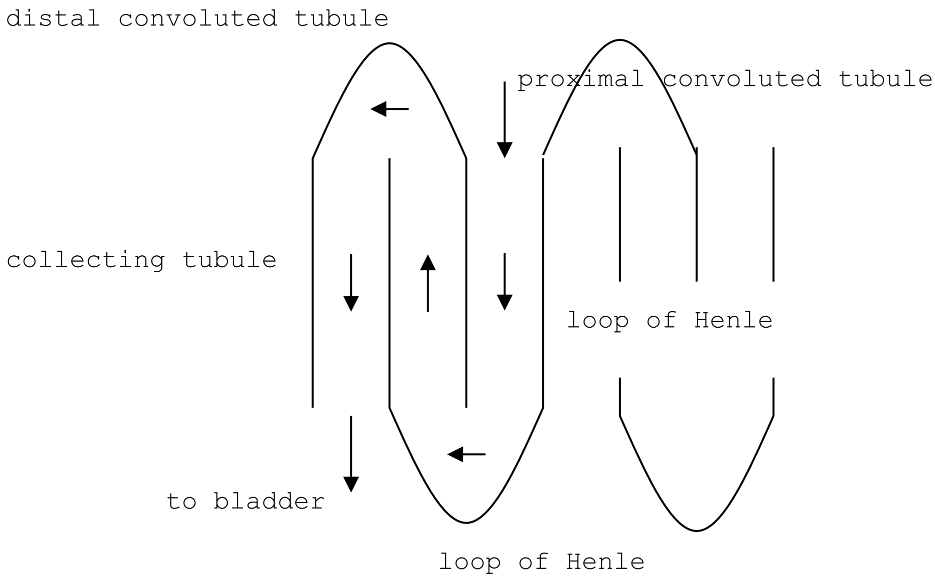
R1-S4T1

The frequencies of quality values will change in each generation of offspring.

4>Zoology>Organ>Excretion
countercurrent mechanism

4/Zoology/Organ/Excretion/countercurrent mechanism.html

Figure 1



distal convoluted tubule
proximal convoluted tubule
collecting tubule
loop of Henle
to bladder
loop of Henle

4>Zoology>Organ>Nerve>Neuron>Types
ganglion cell types

4/Zoology/Organ/Nerve/Neuron/Types/ganglion cell types.html

Figure 1

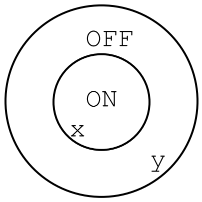


Figure 2

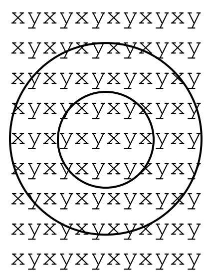

xyxyxyxyxyxy
xyxyxyxyxyxy
xyxyxyxyxyxy
xyxyxyxyxyxy
xyxyxyxyxyxy
xyxyxyxyxyxy
xyxyxyxyxyxy
xyxyxyxyxyxy
xyxyxyxyxyxy

Figure 3

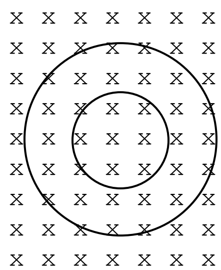


Figure 4

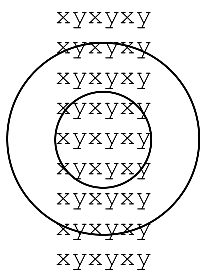

xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy

Figure 5

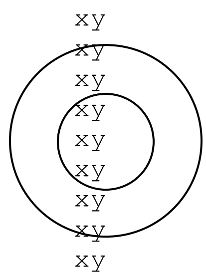


Figure 6

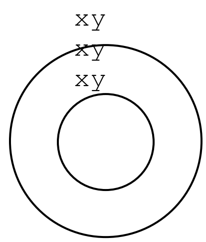


Figure 7

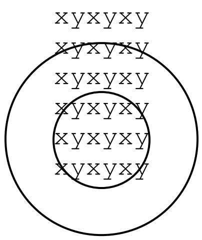


Figure 8

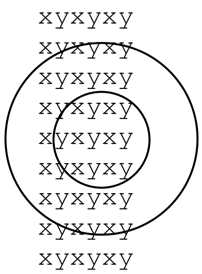

xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy

Figure 9

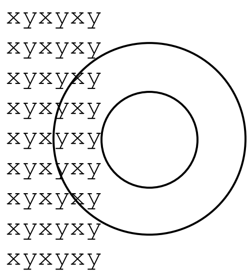
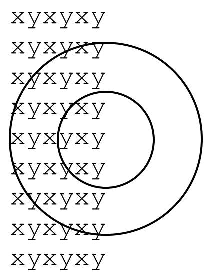

xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy

Figure 10


xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy
xyxyxy

4>Zoology>Organ>Nerve>Neuron>Types
simple cell

4/Zoology/Organ/Nerve/Neuron/Types/simple cell.html

Figure 1

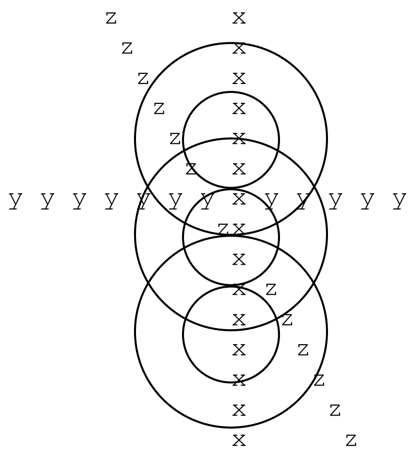


Figure 2

A topographic map has an array of orientation columns.
In a topographic map, each orientation column is for one orientation.
To simplify, use four orientations: - \ | /
The four orientations are for one direction in space.
The array around a central - can look like this:

```
- \ | / - \ | / -
- \ | / - \ | / -
- \ | / - \ | / -
- \ | / - \ | / -
- \ | / + \ | / -
- \ | / - \ | / -
- \ | / - \ | / -
- \ | / - \ | / -
- \ | / - \ | / -
```

or

```
                -
              /   -
            |   /   -
          \   |   /   -
        -   \   |   /   -
      /   -   \   |   /   -
    |   /   -   \   |   /   -
  \   |   /   -   \   |   /   -
-   \   |   /   +   \   |   /   -
  -   \   |   /   -   \   |   /
    -   \   |   /   -   \   |
      -   \   |   /   -   \
        -   \   |   /   -
          -   \   |   /
            -   \   |
              -   \
                -
```

Each orientation column has only the same or the next angle orientation around it.
The array repeats by fours on the vertical, horizontal, and one diagonal and by ones on one diagonal.

5>Astronomy>Universe>Cosmology>Speculation
What Existed Before Multiverse

5/Astronomy/Universe/Cosmology/Speculation/What Existed Before Multiverse.html

Figure 1

Start with single non-oriented number/point/thing.

Make single thing into one oriented component/numbers/vectors (xu). Ratio is 1:1.

U(1) line (xu)

Make line into two oriented components/numbers/vectors (xz). Ratio is 2:1.

SU(2) square/rhombus/diamond (xzuz)

Make both lines into three oriented components/numbers/vectors (xo). Ratio is 3:2 (same as 4:3).

SU(3) equilateral triangle (ooo)

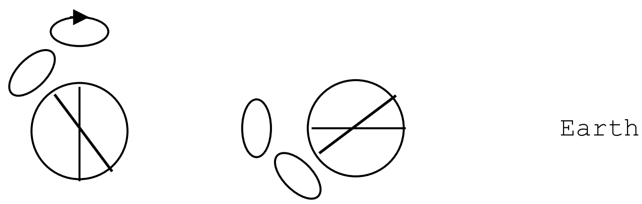
Whole figure is planar. Flipping it makes the same figure, so it has spin 2.

```
                             |           z
                                   o




                 o           x           |           u




                                   o
                             |           z
```

5>Astronomy>Star>Types
pulsar

5/Astronomy/Star/Types/pulsar.html

Figure 1



5>Chemistry>Biochemistry>Drug>Activity deconvolution in arrays

5/Chemistry/Biochemistry/Drug/Activity/deconvolution in arrays.html

Figure 1

1 2 3 4 5 6 7 8 9 0

12	23	34	45	56	67	78	89	90	01
13	24	35	46	57	68	79	80	91	02
14	25	36	47	58	69	70	81	92	03
15	26	37	48	59	60	71	82	93	04
16	27	38	49	50	61	72	83	94	05
17	28	39	40	51	62	73	84	95	06
18	29	30	41	52	63	74	85	96	07
19	20	31	42	53	64	75	86	97	08
10	21	32	43	54	65	76	87	98	09
C	C	C	C	C	C	C	C	C	C

5>Chemistry>Inorganic Chemistry>Chemical Reaction transition-state

5/Chemistry/Inorganic Chemistry/Chemical Reaction/transition-state.html

Figure 1

Figure 2

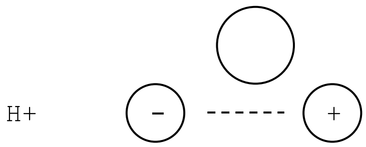
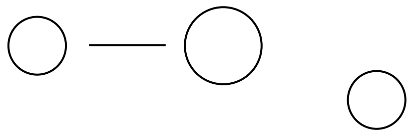


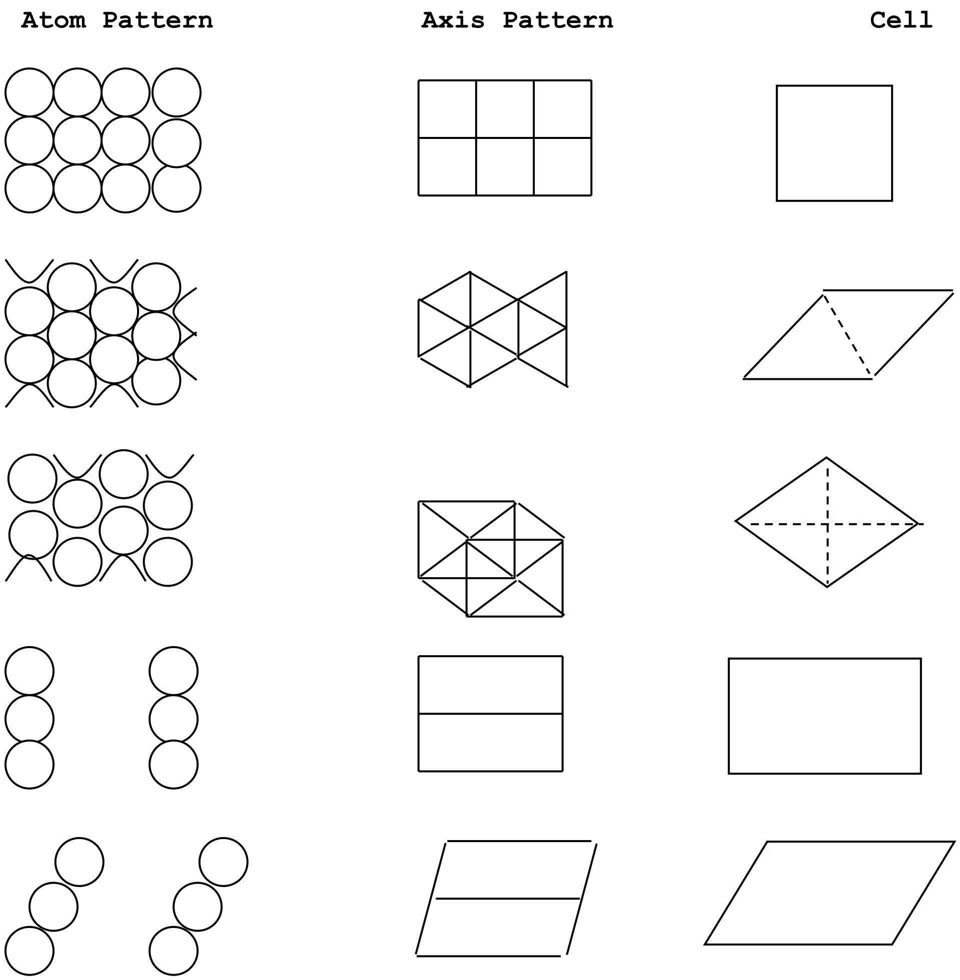
Figure 3



5>Chemistry>Inorganic Chemistry>Phase>Phases>Solid>Crystal>Lattice
Bravais lattice

5/Chemistry/Inorganic/Phase/Phases/Solid/Crystal/Lattice/Bravais_lattice.html

Figure 1



5>Chemistry>Inorganic Chemistry>Phase>Solution osmosis

5/Chemistry/Inorganic Chemistry/Phase/Solution/osmosis.html

Figure 1

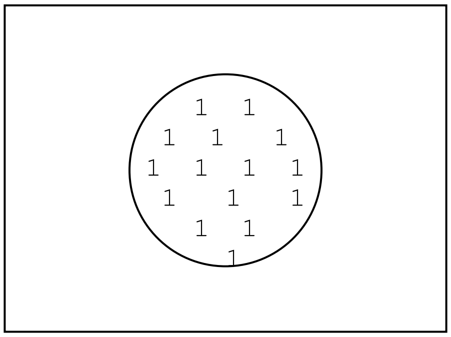
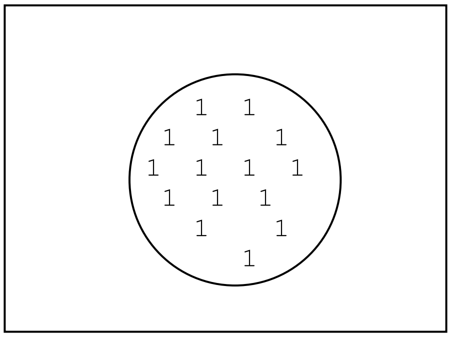


Figure 2



5>Chemistry>Organic Chemistry>Chemical Reaction
addition reaction

5/Chemistry/Organic Chemistry/Chemical Reaction/addition reaction.html

Figure 1

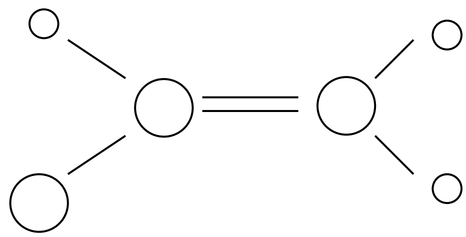


Figure 2

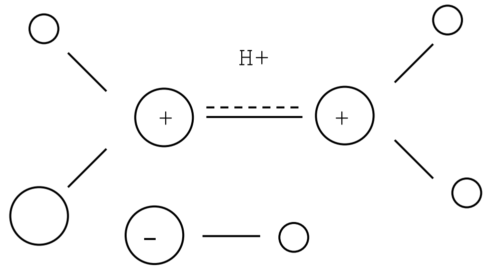
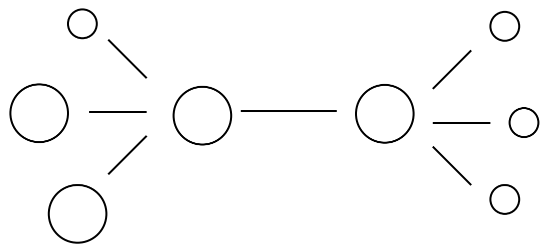


Figure 3



5>Chemistry>Organic Chemistry>Chemical Reaction
electrophilic addition

5/Chemistry/Organic Chemistry/Chemical Reaction/electrophilic addition.html

Figure 1

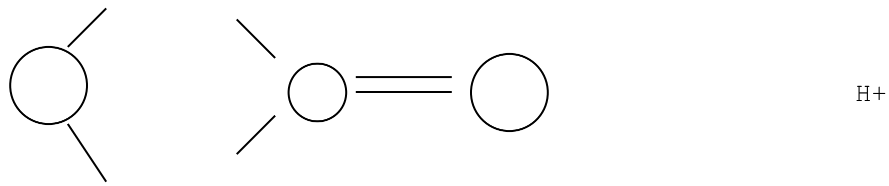


Figure 2

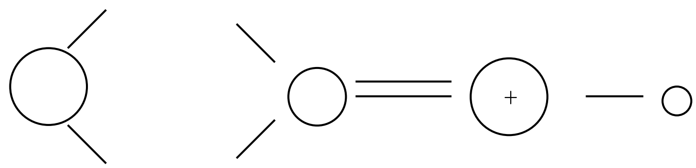


Figure 3

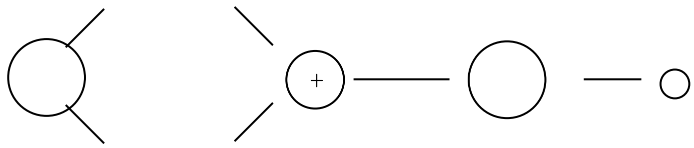
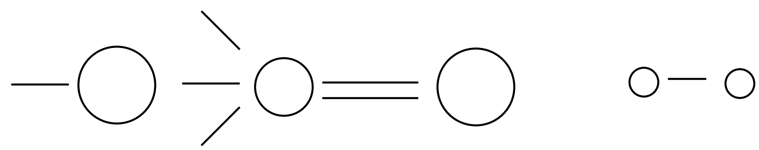


Figure 4



5>Chemistry>Organic Chemistry>Chemical Reaction
elimination reaction

5/Chemistry/Organic Chemistry/Chemical Reaction/elimination reaction.html

Figure 1

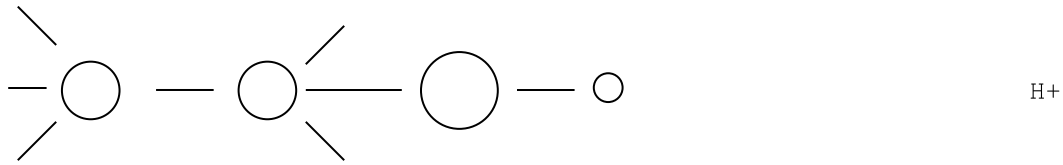


Figure 2

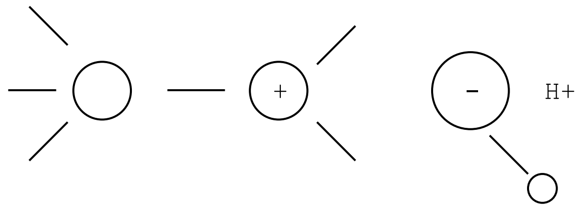
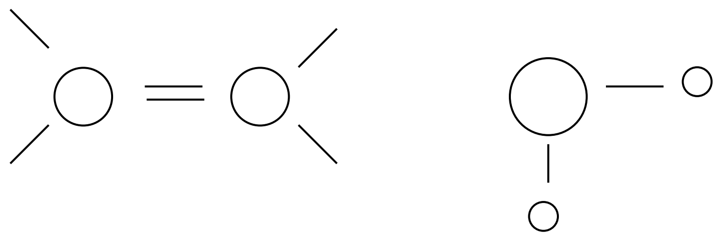


Figure 3



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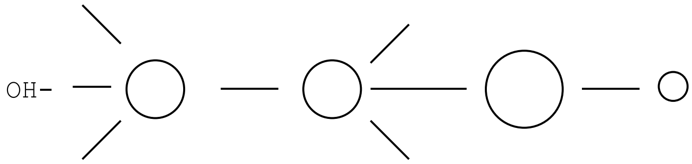

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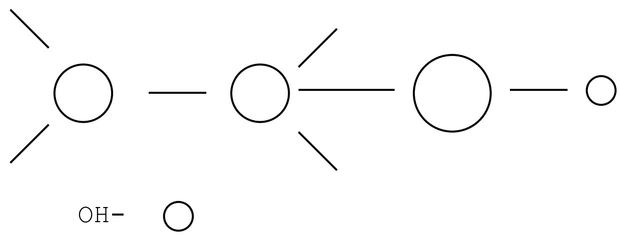

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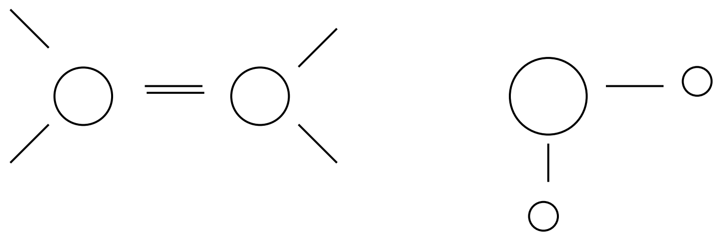

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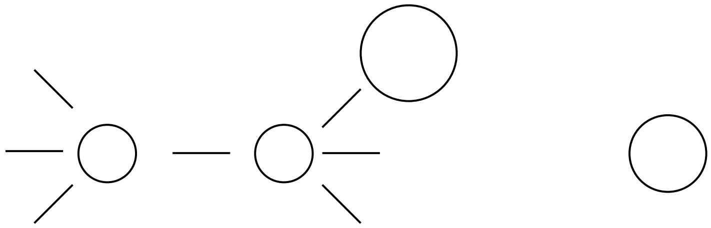

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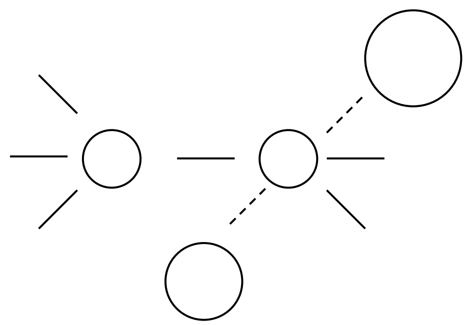
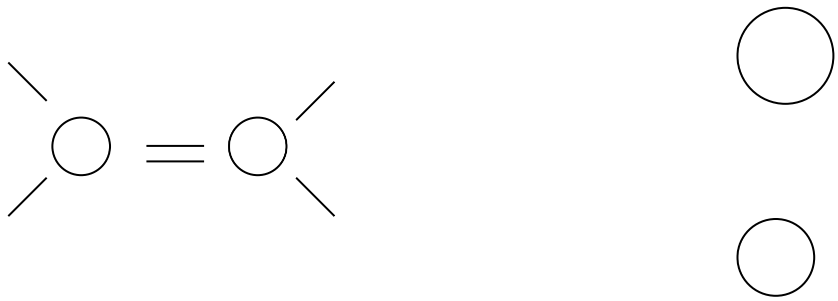


Figure 9



5>Chemistry>Organic Chemistry>Chemical Reaction
nucleophilic addition

5/Chemistry/Organic Chemistry/Chemical Reaction/nucleophilic addition.html

Figure 1

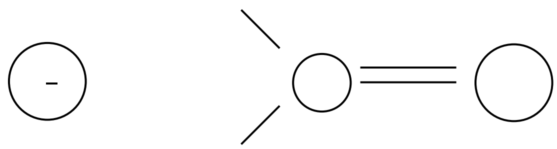


Figure 2

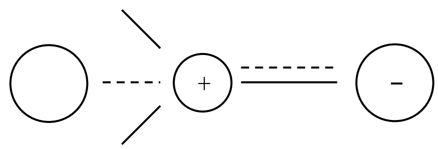
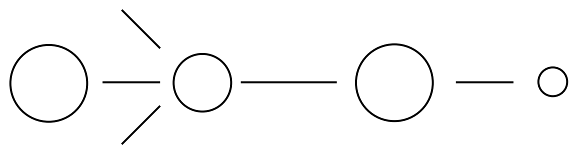


Figure 3



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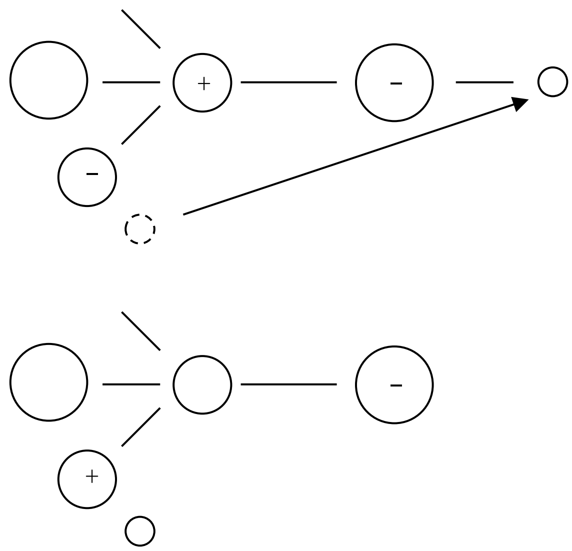
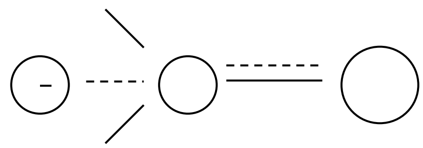
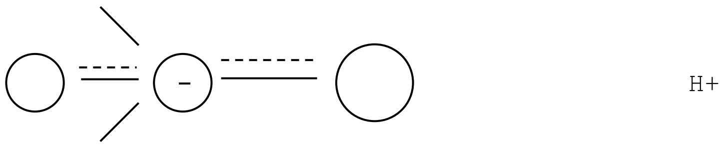


Figure 5



H+

Figure 6



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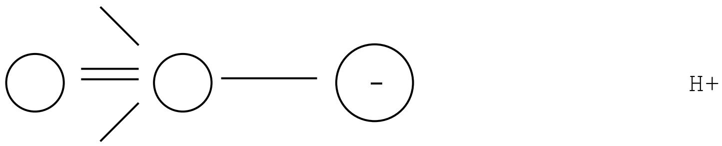

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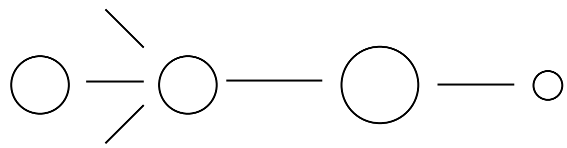


Figure 9

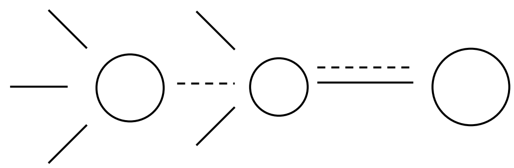
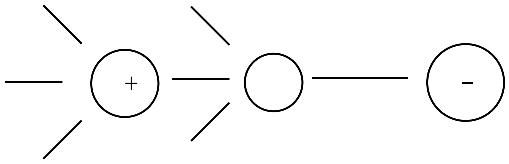


Figure 10



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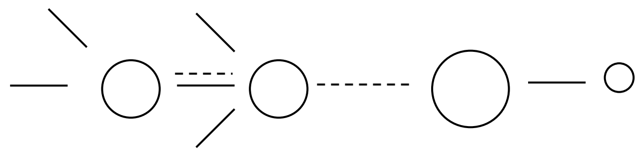

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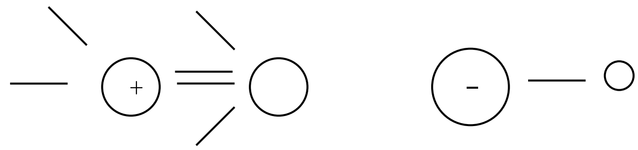

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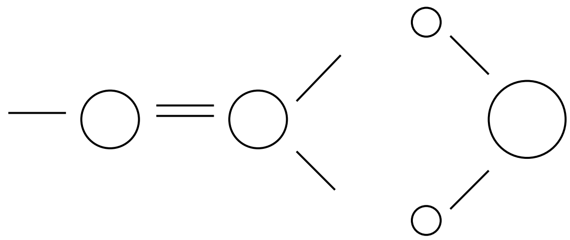


5>Chemistry>Organic Chemistry>Chemical Reaction substitution reaction organic

5/Chemistry/Organic Chemistry/Chemical Reaction/substitution reaction organic.html

Figure 1

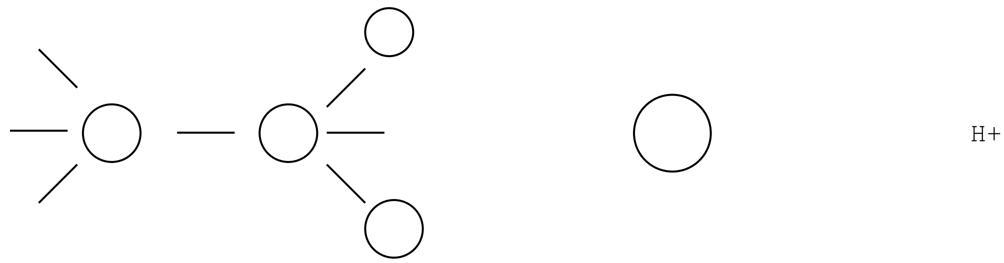
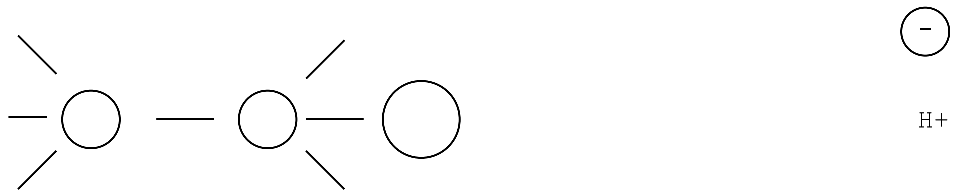


Figure 2

Figure 3



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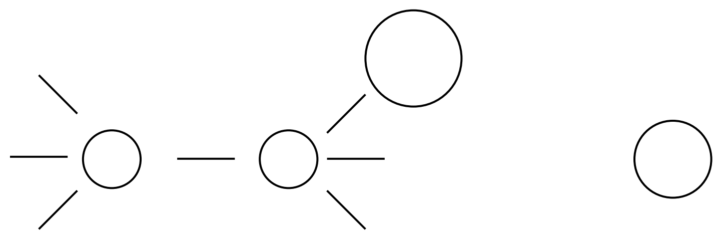


Figure 5

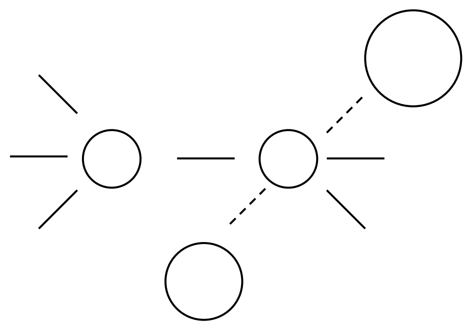
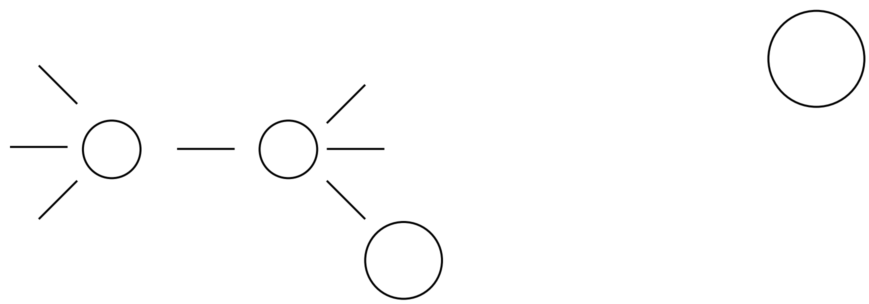


Figure 6



5>Earth Science>Planet>Plate Tectonics
plate tectonics

5/Earth Science/Planet/Plate Tectonics/plate tectonics.html

Figure 1

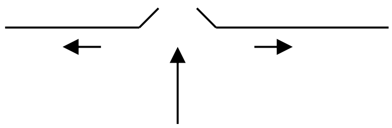
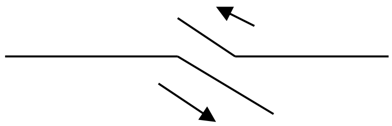


Figure 2



5>Physics>Matter>Atom>Orbital spin

5/Physics/Matter/Atom/Orbital/spin.html

Figure 1

Spin 0

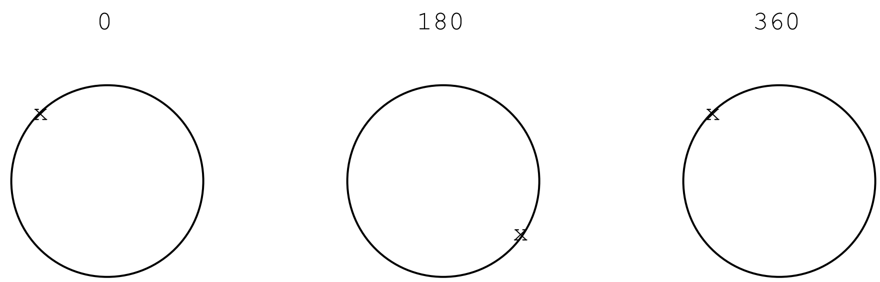


Figure 2

Spin 1

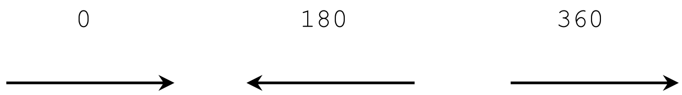


Figure 3

Spin 2

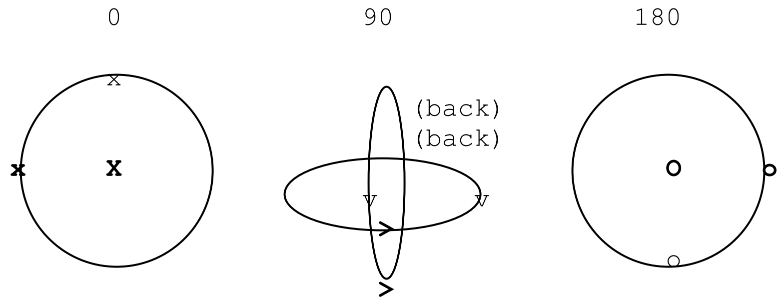
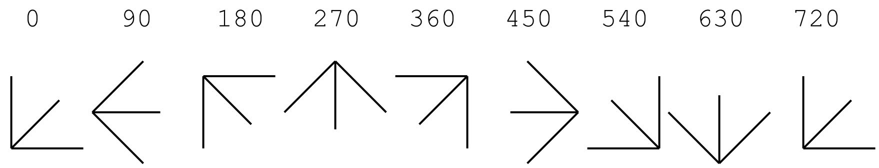


Figure 4

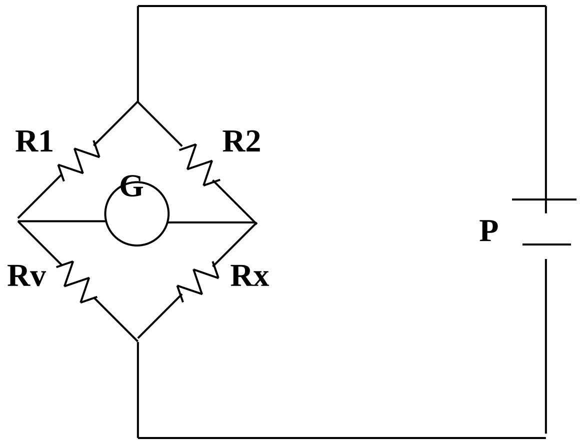
Spin 1/2



5>Physics>Electromagnetism>Circuit>Kinds>Instruments Wheatstone bridge

5/Physics/Electromagnetism/Circuit/Kinds/Instruments/Wheatstone bridge.html

Figure 1
Wheatstone bridge



R1, R2, Rv, and Rx are resistances.
P is potential.
G is galvanometer.

5>Physics>Electromagnetism>Magnetism
magnetism electric

5/Physics/Electromagnetism/Magnetism/magnetism_electric.html

Figure 1

Wires at rest and current = 0.
Stationary observers

```
    +  +  +  +  +  +  +  +  +  +                v = 0
   -  -  -  -  -  -  -  -  -  -                 v = 0

   -  -  -  -  -  -  -  -  -  -                 v = 0
    +  +  +  +  +  +  +  +  +  +                v = 0
```

Both wires have equal charges, so no net charge or force occurs.

Figure 2

Wires at rest and one current > 0.

Stationary proton observers and electron observer

```
    +  +  +  +  +  +  +  +  +  +                v = 0
     - - - - - - - - - - - - - -       ->       v > 0

   -  -  -  -  -  -  -  -  -  -                 v = 0
    +  +  +  +  +  +  +  +  +  +                v = 0
```

Stationary proton observers on wire with current see no net charge on the other wire.

Stationary proton observers on the wire with no current see relativistic net negative charge on the other wire.

Stationary electron observers on the wire with no current see relativistic net negative charge on the other wire.

Moving electron observer

```
    +  +  +  +  +  +  +  +  +  +                v = 0
     - - - - - - - - - - - - - -       ->       v > 0

   -  -  -  -  -  -  -  -  -  -                 v = 0
    +  +  +  +  +  +  +  +  +  +                v = 0
```

Moving electron observers on the wire with current see no net charge on the other wire.

The two forces cancel, so net force is zero.

Figure 3

Wires at rest and opposite currents.

Stationary proton observers

```
    +  +  +  +  +  +  +  +  +  +                v = 0
     - - - - - - - - - - - - - -       ->       v > 0

     - - - - - - - - - - - - - -       <-       v < 0
    +  +  +  +  +  +  +  +  +  +                v = 0
```

Protons in each wire see a smaller relativistic net negative charge on the other wire, so small attraction.

Moving electron observers, in opposite directions

```
    + + + + + + + + + + + + + +             v = 0
     ---------------------------    ->      v > 0

     ---------------------------    <-      v < 0
    + + + + + + + + + + + + + +             v = 0
```

Electrons in each wire see a greater relativistic net negative charge on the other wire, so large repulsion.

Net force is repulsion.

Figure 4
Wires at rest and same currents.
Stationary proton observers

```
    +  +  +  +  +  +  +  +  +  +                v = 0
     - - - - - - - - - - - - - -       ->       v > 0

     - - - - - - - - - - - - - -       ->       v > 0
    +  +  +  +  +  +  +  +  +  +                v = 0
```

Protons in each wire see a relativistic net negative charge on the other wire.

Moving electron observers, in same direction

```
    + + + + + + + + + + + + + +              v = 0
     -  -  -  -  -  -  -  -  -      ->       v > 0

     -  -  -  -  -  -  -  -  -      ->       v > 0
    + + + + + + + + + + + + + +              v = 0
```

Electrons in each wire see a relativistic net positive charge on the other wire.

Net force is attraction.

Figure 5

+-   -

Figure 6

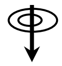
+- - 

Figure 7

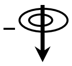
+-  -

Figure 8

Figure 9

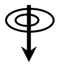
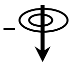
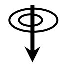
\+ –  –

Figure 10

+- 

\- 

5>Physics>Heat>Entropy
entropy and heat

5/Physics/Heat/Entropy/entropy and heat.html

Figure 1

```
1  ->  many

11111         1  1  1  1  1
11111  ->
11111         1  1  1  1  1

              1  1  1  1  1


1  1  1     1         1     1     1
1  1  1                        1
1  1  1          ->    1    1    1
                        1      1
1           1         1     1     1
```

5>Physics>Heat>Statistical Mechanics distribution of energies

5/Physics/Heat/Statistical Mechanics/distribution of energies.html

Figure 1

ground state + one quantum	Q1
ground state energy	Q0

Figure 2

ground state + two quanta		Q2#1	Q2#2
ground state + one quantum	Q1#1, Q1#2		
ground state energy		Q0#2	Q0#1

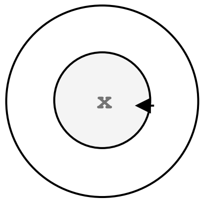
Figure 3

ground state + two quanta		Q2#1	Q2#2
ground state + one quantum	Q1#1, Q1#2		
ground state energy		Q0#2	Q0#1

5>Physics>Quantum Mechanics
atom stability

5/Physics/Quantum Mechanics/atom stability.html

Figure 1



5>Physics>Quantum Mechanics
entanglement

5/Physics/Quantum Mechanics/entanglement.html

Figure 1

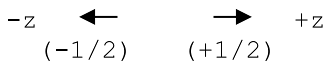
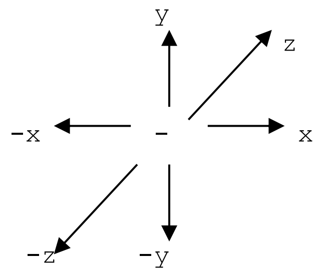


Figure 2



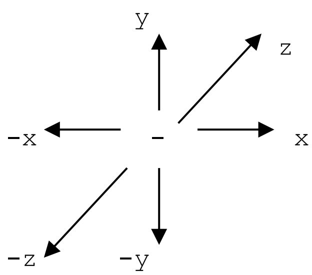


Figure 3

Quantum mechanics goes into states randomly and so does not correlate left-electron and right-electron spins.

If left electron is z+, right electron is:

x- or y+ or z- 25% of time
x+ or y- or z- 25% of time
x- or y- or z- 25% of time
x+ or y+ or z- 25% of time

For right-electron z-axis compared to left-electron z-axis, spins are opposite all of the time:
z+z-
z+z-
z+z-
z+z-

For right-electron x-axis or y-axis compared to left-electron z-axis, spins are same 1/2 of time and opposite 1/2 of time:
z+x-, z+y+
z+x+, z+y-
z+x-, z+y-
z+x+, z+y+

If left electron is z-, right electron is:

x- or y+ or z+ 25% of time
x+ or y- or z+ 25% of time
x- or y- or z+ 25% of time
x+ or y+ or z+ 25% of time

By symmetry with the above:
For right-electron z-axis compared to left-electron z-axis, spins are opposite all of the time.
For right-electron x-axis or y-axis compared to left-electron z-axis, spins are same 1/2 of time and opposite 1/2 of time.

Figure 4

Non-random quantum mechanics correlates left and right electron results:

If left electron is z+:
If left=x+y+z+, right=x-y-z- 25% of time.
If left=x-y+z+, right=x+y-z- 25% of time.
If left=x+y-z+, right=x-y+z- 25% of time.
If left=x-y-z+, right=x+y+z- 25% of time.

left=x+y+z+, right=x-y-z- has the pairs:
x+x-, x+y-, x+z-, y+x-, y+y-, y+z-, z+x-, z+y-, z+z-
so spins are same 0 times and opposite 9 times.
.
left=x-y+z+, right=x+y-z- has the pairs:
x-x+, x-y-, x-z-, y+x+, y+y-, y+z-, z+x+, z+y-, z+z-
so spins are same 4 times and opposite 5 times.

left=x+y-z+, right=x-y+z- 25% of time.
x+x-, x+y+, x+z-, y-x-, y-y+, y-z-, z+x-, z+y+, z+z-
so spins are same 4 times and opposite 5 times.

left=x-y-z+, right=x+y+z- 25% of time.
x-x+, x-y+, x-z-, y-x+, y-y+, y-z-, z+x+, z+y+, z+z-
so spins are same 4 times and opposite 5 times.

If left electron is z+:
If left=x-y-z-, right=x+y+z+ 25% of time.
If left=x+y-z-, right=x-y+z+ 25% of time.
If left=x-y+z-, right=x+y-z+ 25% of time.
If left=x+y+z-, right=x-y-z+ 25% of time.

Because of symmetry, same numbers and probabilities as above.

5>Physics>Quantum Mechanics
uncertainty principle

5/Physics/Quantum Mechanics/uncertainty principle.html

Figure 1

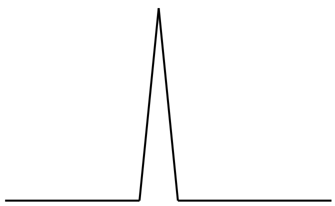


Figure 2

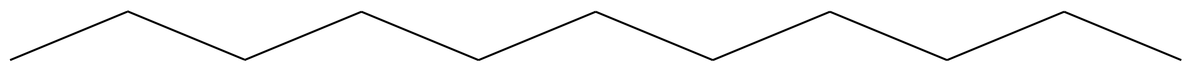


Figure 3

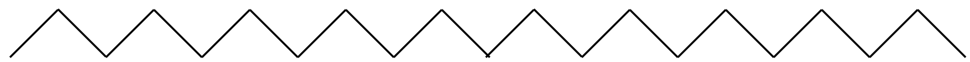
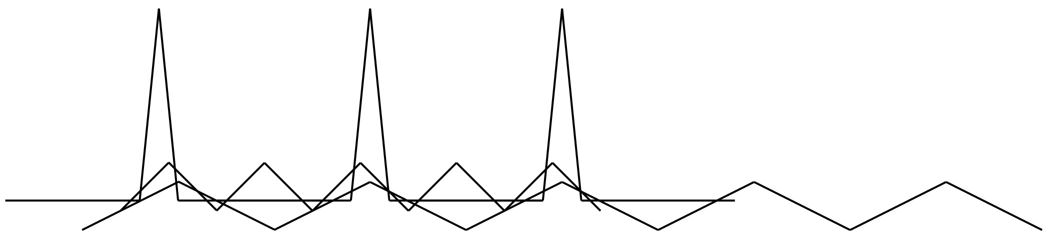


Figure 4

Figure 5



5>Physics>Quantum Mechanics>Quantum
quantum of energy

5/Physics/Quantum Mechanics/Quantum/quantum of energy.html

Figure 1

.
.
.

ground state + 3 quanta	Q4
ground state + 2 quanta	Q3
ground state + 1 quantum	Q2
ground state energy	Q1

Figure 2

```
       Q   Q   Q   Q   Q
   |   |   |   |   |   |
  Q1  Q2  Q3  Q4  Q5  Q6  ...
```

Figure 3

1111111111111111111111111 ...

5>Physics>Relativiity relativity

5/Physics/Relativity/relativity.html

Figure 1

```
           |t
           |
           |
---------------------- x
           |
```

Figure 2

```
          |
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Figure 3

```
          |  /
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Figure 4

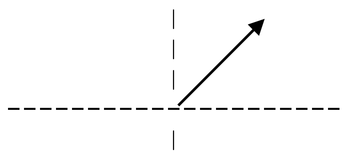


Figure 5

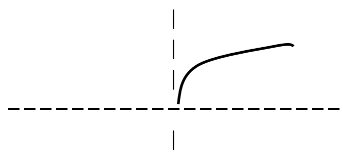


Figure 6

```
          |  s4
          s2 s3 s5
          |
----------s1---------
          |
```

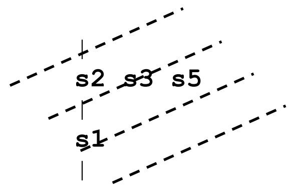
Figure 7

```
          |
          s2 s3 s5
          |
----------s1--------------
          |
```

Figure 8

```
          |
          | s5
          s3
        s2|
----------s1--------------
          |
```

Figure 9



5>Physics>Relativity
E equals m c squared

5/Physics/Relativity/E equals m c squared.html

Figure 1

```
E = PE      + KE
E = m0*c^2               + m0*(v^2)/2    + 3*m0*(v^4)/8*c^2  + ...
E = m0*(c^2 + c0*(v^2)^0 + c1*(v^2)^1  + c2*(v^2)^2       + c3*(v^2)^3 + ...)
E = m0*(c^2 + 0          + (0.5)*(v^2)^1 + (3/8*c^2)*(v^2)^2 + ...)
```

5>Physics>Relativity
relative velocity

5/Physics/Relativity/relative velocity.html

Figure 1

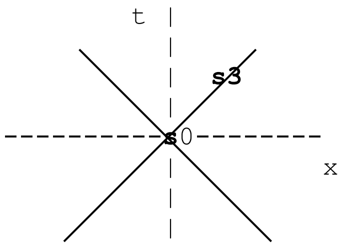


Figure 2

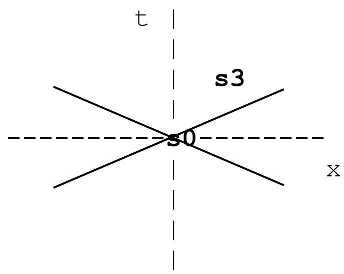
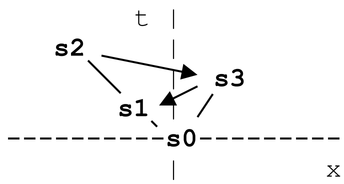


Figure 3



5>Physics>Relativity>Space-Time simultaneity

5/Physics/Relativity/Space-Time/simultaneity.html

Figure 1

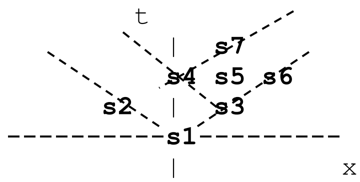


Figure 2

```
        t
          |  s7
          s4 s5 s6
      s2  |  s3
----------s1---------
          |          x
```

5>Physics>Relativity>Special Relativity
length contraction

5/Physics/Relativity/Special Relativity/length contraction.html

Figure 1

```
         |- - - - -|   ruler with v = 0
observer      ^


   ->      |-----|     same ruler with v > 0
observer      ^        leading point is ahead in time and behind in space
                       trailing point is behind in time and ahead in space
```

Figure 2

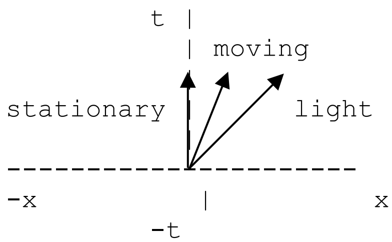


Figure 3

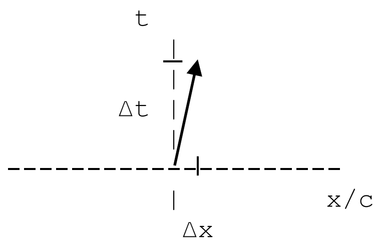
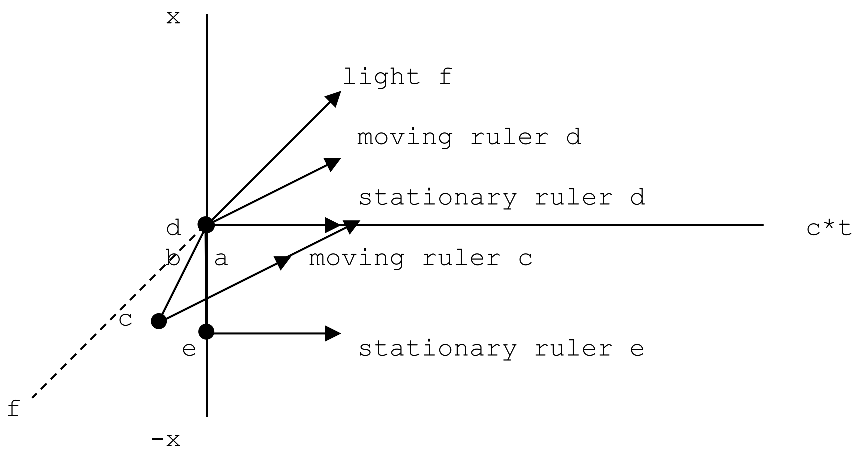


Figure 4

```
A stationary observer is at one end of a stationary ruler.
The signal travels from end to end and back.
         |-----|      ruler with v = 0
         ] <-> ^      observer

A stationary observer is at one end of a moving ruler.
The signal starts to travel from end to end.
         |-----|      ruler with v > 0
         ]   <-^      observer

The ruler moves as the signal travels and reflects earlier.
          |-----|     ruler with v > 0
          ]<-  ^      observer

It returns in the same time as it went.
           |-----|    ruler with v > 0
          ]  ->^      observer

The time is shorter and the ruler has shorter length.
```

Figure 5



stationary ruler space-time length = a = b = moving ruler space-time length

a^2 + 0^2 = (((3^0.5)/2)^2)*b^2 + (b/2)^2

Angle between d and e is 90 degrees for stationary.
Angle between light f and f is 180 degrees.
Angle between moving ruler d and c is 135 degrees.

5>Physics>Relativity>Special Relativity
time dilation

5/Physics/Relativity/Special Relativity/time dilation.html

Figure 1

```
       |- - - - -|     clock with v = 0
observer    ^


 ->  |-  -  -  -  -|   same clock with v > 0
observer    ^          leading beat is ahead in time and behind in space
                       trailing beat is behind in time and ahead in space
```

Figure 2

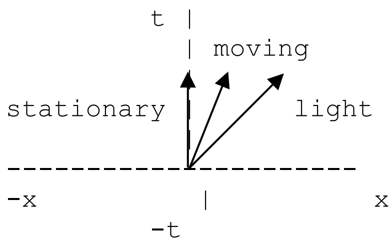


Figure 3

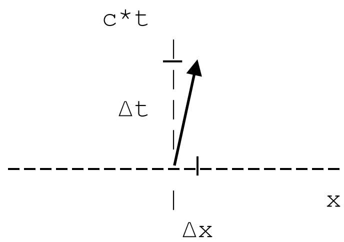


Figure 4

A stationary observer is beside a stationary clock.
The clock has a resonant oscillation from end to end.

```
         |-----|      clock with v = 0
         ] <-> ^      observer
```

A stationary observer is at one end of a moving clock.
The wave starts to travel from end to end.

```
         |-----|      clock with v > 0
         ]   <-^      observer
```

The clock moves as the signal travels and reflects the resonance earlier.

```
          |-----|     clock with v > 0
          ]<-  ^      observer
```

It returns to the observer in the same time as it went,
but it has not completed one oscillation.

```
           |-----|    clock with v > 0
          ]  ->^      observer
```

It continues on, to reflect.

```
            |-----|   clock with v > 0
          ]    ^->    observer
```

It reaches the observer.

```
             |-----|  clock with v > 0
          ]    ^<-    observer
```

The time interval is longer because the resonance distance is longer.
The measured time will be less.

5>Physics>Relativity>Special Relativity
mass increase

5/Physics/Relativity/Special Relativity/mass increase.html

Figure 1

```
       |- - - - -|      mass with v = 0
test mass   ^           mass is moving only through time at light speed
                        so only the rest mass is in space-time.

 ->  |-  -  -  -  -|   same mass with v > 0
test mass   ^           mass is moving through time and space
                        so rest mass increases.
```

Figure 2

```
A stationary test mass is beside a stationary mass.
The mass has a rest mass (m0 = E/c^2) due to matter, but no kinetic energy.
         |-----|      mass with v = 0
               ^      test mass

A stationary test mass is at one end of a moving mass.
The mass has rest mass (m = E/c^2) plus kinetic energy: 0.5*m*(v^2).
         |-----|      mass with v > 0
            |--|      kinetic energy
               ^      test mass

The kinetic energy has mass: m = 2*KE/(v^2) = 2*(p*(v/2))/(v^2) = p/v.
          |-----|     mass with v > 0
             |--|     mass due to kinetic energy
               ^      test mass

Total mass = m0 + m = E/c^2 + p/v.
```

Figure 3

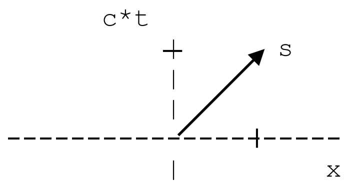
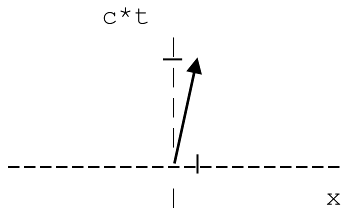


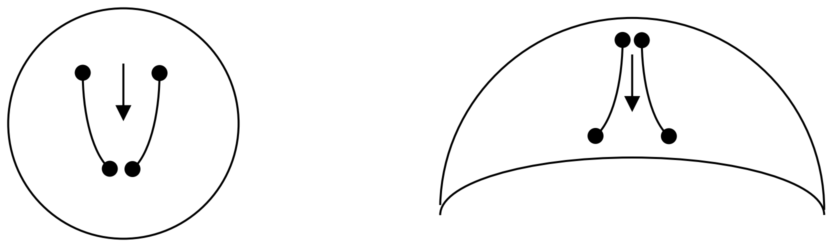
Figure 4



5>Physics>Relativity>General Relativity>Curvature>Geodesics geodesic on surface

5/Physics/Relativity/General Relativity/Curvature/Geodesics/geodesic on surface.html

Figure 1



Sphere Saddle

5>Physics>Relativity>General Relativity>Gravity gravitational pressure

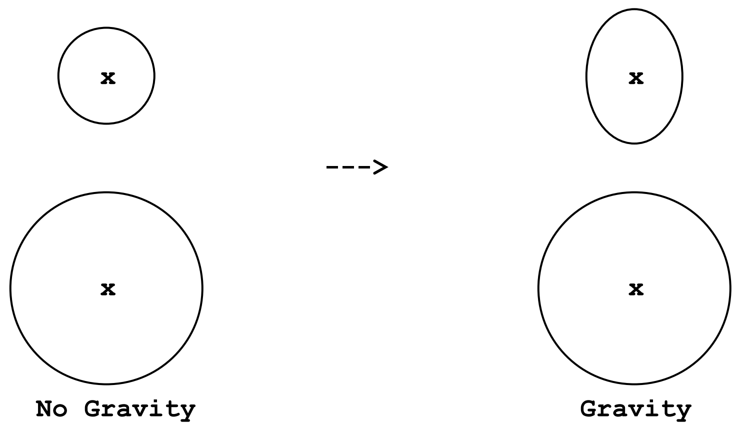
5/Physics/Relativity/General Relativity/Gravity/gravitational pressure.html

Figure 1

5>Physics>Relativity>General Relativity>Gravity
tidal force

5/Physics/Relativity/General Relativity/Gravity/tidal force.html

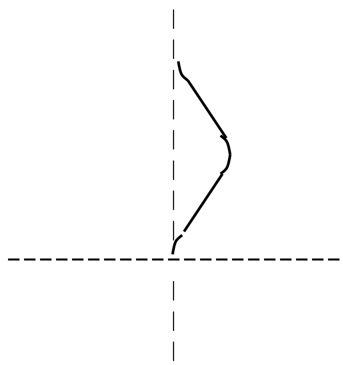
Figure 1



5>Physics>Relativity>General Relativity>Time
twin paradox

5/Physics/Relativity/General Relativity/Time/twin paradox.html

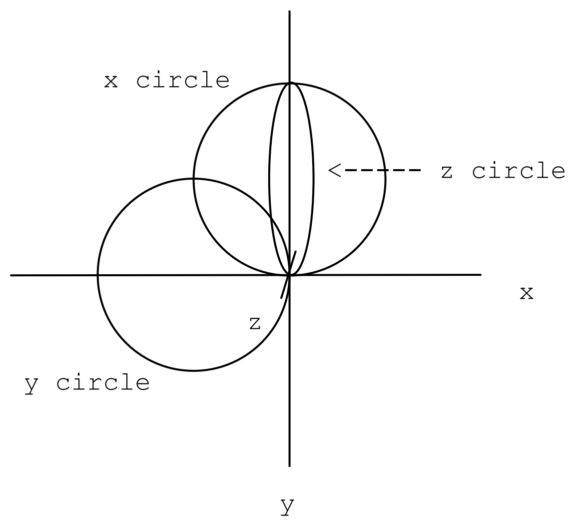
Figure 1



5>Physics>String Theory>Dimensions
Calabi-Yau shapes

5/Physics/String Theory/Dimensions/Calabi-Yau shapes.html

Figure 1



5>Physics>Wave
Doppler effect

5/Physics/Wave/Doppler effect.html

Figure 1

```
   <-  | | | | | | | | | | x
        <)

 <-  | | | | | | | | | | | x
        <)
```

Figure 2

```
      <-    | | | | | | | | | | x
          <) ->

     <-  | | | | | | | | | | | x
           <) ->
```

Figure 3

```
             <-  | | | | x
           <-  | | | || x <-
         <-  | | | ||| x <-
       <-  | | | |||| x <-
     <-  | | | ||||| x <-
   <-  | | | |||||| x <-
 <-  | | | ||||||| x <-
            <)

     <-  ||||||| x <-
            <)
```

Figure 4

```
       <-  | | | | | | | | | | x
       <- <)

     <-  | | | | | | | | | | | x
      <- <)
```

Figure 5

```
              <-  | | | | | | x
            <-  | | | | | |  |x ->
          <-  | | | | | |  |  |x ->
        <-  | | | | | |  |  |  |x ->
      <-  | | | | | |  |  |  |  |x ->
    <-  | | | | | |  |  |  |  |  |x ->
  <-  | | | | | |  |  |  |  |  |  |x ->
<-  | | | | | |  |  |  |  |  |  |  |x ->
                <)

        <-  |  |  |  |  |  |  |  |  |x ->
                <)
```

5>Physics>Wave>Electromagnetic
electromagnetic wave induction

5/Physics/Wave/Electromagnetic/electromagnetic wave induction.html

Figure 1

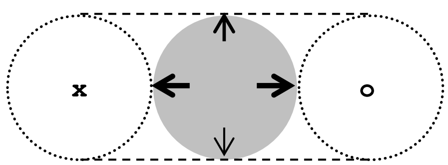
Time 0 - Constant-Velocity Electron, with No Electromagnetic Waves

At position 1, before stopping at metal plate, electron (gray) travels vertically downward at constant velocity. Its electric and magnetic fields have the same constant velocity. Electric field and magnetic field begin at electron edge, which emits virtual photons.

Relativistic length contraction makes electric field (arrows) appear stronger horizontally (positions 2) to observer. Electric field appears weaker vertically (position 1) to observer. Vertical electric field is foreshortened in motion direction. Vertical electric field is lengthened opposite to motion direction.

Positions 5 through 3 and 3 through 5 have adjacent magnetic force as a torus around moving electron. Electron has negative charge, so magnetic field is out on left and in on right, by right-hand rule.

Magnified View of Pre-Deceleration Electric and Magnetic Fields



Position 5 4 32 1 23 4 5

Observation line is through electron center, perpendicular to vertical-motion line.

x's represent points, as vectors coming out of paper plane. Circles represent points, as vectors going into paper plane.
Displayed vectors indicate electric-field push/pull direction. They have no spatial length through space.
Bolder lines indicate higher field strengths. Lighter lines indicate lower field strengths.

Point View of Pre-Deceleration Magnetic Field

Time 0 **x**e**o**

Position 012345

Magnetic field is out on left and in on right.

Transverse Electric-Field Line

Time 0 e————————————————

Virtual photons stream straight outward at light speed from electron in all directions.

Figure 2

Time 1 - Deceleration Begins, and Kinetic Energy Changes to Potential Energy

At position 1, force causing electron deceleration also puts transverse upward pushing force on field lines and distorts electric-field lines.

At position 1, as electron slows down, electric-field upward transverse component increases over time. Position-1 has induced magnetic field. Position-2 begins induced magnetic field.

At position 1, induced magnetic field increases over time. Position-1 has induced electric field. Position-2 begins induced electric field.

At positions 2 and higher, horizontal electric-field lines continue moving at constant velocity. Transverse electric-field-line component stretches downward. Transverse electric-field-line component moves outward at light speed.

Point View of Induced Electric and Magnetic Fields

Time 1 e

Position 012345

Transverse Electric-Field Line

Time 1 e-

Figure 3

Time 2 - Deceleration Middle - Restoring Force Changes Kinetic Energy into Potential Energy

At position 1, as electron slows down more, electric-field-line points at electron edge slow down more, so horizontal electric-field lines have greater transverse component.

At position 1, electric-field upward transverse component increases over time and so makes induced-magnetic-field gradient. Position-1 has bigger induced magnetic field. Position-2 has induced magnetic field.

At position 1, induced magnetic field increases over time and so makes induced-electric-field gradient. Position-1 has bigger induced electric field. Position-2 has induced electric field.

At position 2, position-1 electric-field upward transverse component increases over time and so makes induced-magnetic-field gradient. Position-2 has induced magnetic field. Position-3 begins induced magnetic field.

At position 2, position-1 induced magnetic field increases over time and so makes induced-electric-field gradient. Position-2 has induced electric field. Position-3 begins induced electric field.

At positions 3 and higher, horizontal electric-field lines continue moving at constant velocity. Transverse electric-field-line component stretches farther downward. Transverse electric-field-line component moves outward at light speed.

Point View of Induced Electric and Magnetic Fields

Time 2 

Position 012345

Transverse Electric-Field Line

Time 2 

Figure 4

Time 3 - Deceleration End - Restoring Force Changes All Kinetic Energy into Potential Energy

Metal plate stops electron within one electron width.

At position 0, electron is at zero velocity, original electric field is symmetric, and original magnetic field is zero.

At position 1, electric-field-line ends stop, so horizontal electric-field lines have maximum transverse component.
At position 1, electric-field upward transverse component has increased to maximum over time and so makes induced-magnetic-field gradient. Position-1 has biggest induced magnetic field. Position-2 has induced magnetic field.
At position 1, induced magnetic field has increased to maximum over time and so makes induced-electric-field gradient. Position-1 has biggest induced electric field. Position-2 has induced electric field.

At position 2, position-1 electric-field upward transverse component increases over time and so makes induced-magnetic-field gradient. Position-2 has big induced magnetic field. Position-3 has induced magnetic field.
At position 2, position-1 induced magnetic field increases over time and so makes induced-electric-field gradient. Position-2 has big induced electric field. Position-3 has induced electric field.

Position 3 is like position 2 in Figure 3.

At positions 4 and higher, horizontal electric-field lines continue moving at constant velocity. Transverse electric-field-line component stretches farther downward. Transverse electric-field-line component moves outward at light speed.

Point View of Induced Electric and Magnetic Fields

Time 3

Position 012345

Transverse Electric-Field Line

Time 3

Figure 5

Time 4 - After Deceleration End - Transverse Electric-Field-Line Component Stretches

At position 1, transverse electric-field stays constant at zero.
At position 1, transverse magnetic field stays constant at zero.
At position 1, electron and electric-field line have no velocity.
At position 1, virtual photon travels horizontally at light speed.

Position 2 is like position 1 in Figure 4.

Position 3 is like position 2 in Figure 4.

Position 4 is like position 3 in Figure 4. Gradient and wave leading edge travel outward at constant light speed.

At positions 5 and higher, horizontal electric-field lines continue moving at constant velocity. Transverse electric-field-line component stretches downward. Transverse electric-field-line component moves outward at light speed.

Point View of Induced Electric and Magnetic Fields

```
Time 4              e ↑↑↑

Position            012345
```

Transverse Electric-Field Line

```
Time 4              e——
                       _
                        _
                         ____________________________________________
```

Figure 7

Time 6 - Traveling Half-Wave

Position 1 is like position 1 in Figure 6.

Position 2 is like position 1 in Figure 6.

Position 3 is like position 2 in Figure 6.

Position 4 is like position 3 in Figure 6.

Position 5 is like position 4 in Figure 6. Gradient and wave leading edge travel outward at constant light speed.

At positions 6 and higher, horizontal electric-field lines continue moving at constant velocity. Transverse electric-field-line component stretches farther downward. Transverse electric-field-line component moves outward at light speed.

Point View of Induced Electric and Magnetic Fields

Time 5 e 

Position 0123456789012

Transverse Electric-Field Line

Time 5 

Future Times

Transverse Electric-Field Line

Time 6 

Times 6 and up continue same pattern as at Time 5, because all interactions are elastic.

5>Physics>Wave>Electromagnetic initiation and propagation

5/Physics/Wave/Electromagnetic/initiation and propagation.html

Figure 1

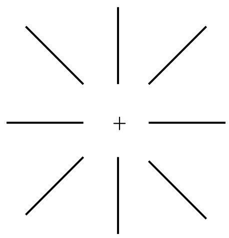
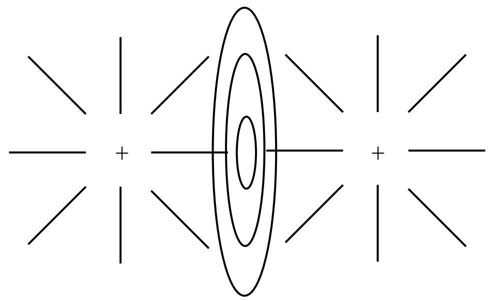
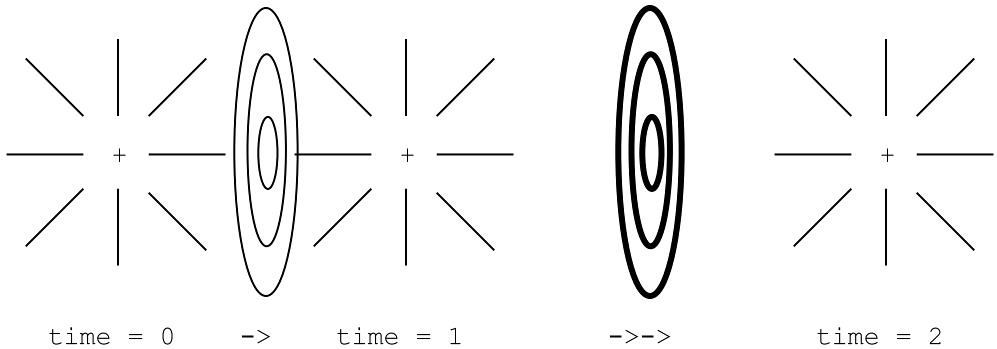


Figure 2



time = 0 --> time = 1

Figure 3



Note: Bolder lines indicate greater field strength.

Figure 4

Time = 0

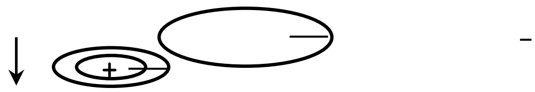
Stationary - test charge

+ charge begins to accelerate downward.
Electric field (horizontal line) starts to shift downward.
Magnetic field (circles) starts to increase, as current increases.

Figure 5

Time = 1

Induced magnetic field (circles) moves at light speed.
Induced electric field (horizontal line) moves at light speed.



Stationary - test charge

+ charge has moved downward.
Acceleration has stopped, at higher velocity.
Magnetic field (circles) has increased and moved downward.
Electric field (horizontal line) has moved downward.

Figure 6

Time = 2

Original electric and magnetic fields continue, at higher constant velocity.
Induced electric and magnetic fields travel horizontally at light speed.

Induced electric field reaches test - charge.
Test - charge accelerates downward.
Induced magnetic field reaches test - charge.
Test - charge accelerates downward,
by right-hand rule.

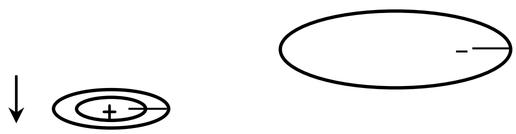


Figure 7

Time = 3

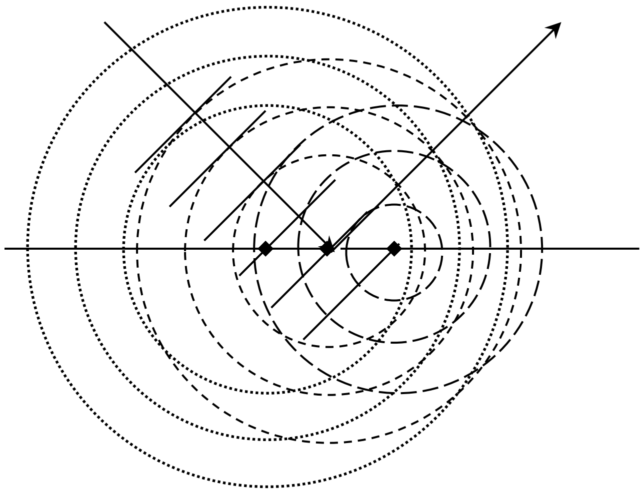
Original electric and magnetic fields continue, at constant velocity.
Induced electric and magnetic fields travel horizontally at light speed.

Induced electric field passes test charge.
Induced magnetic field passes test charge.
Test charge continues downward at constant velocity.

5>Physics>Wave>Properties>Superposition
Huygen's principle

5/Physics/Wave/Properties/Superposition/Huygen's principle.html

Figure 1



The parallel straight lines indicate maximum positive amplitudes of a wave.
The distances between the parallel lines are the wavelength.
If a source is far away, the wave front can be almost a straight line.

A wave front hits the surface first on the left, then continues along the surface.

At the instant of Figure 1, the third wave front from the right hits the surface at the left diamond, the second wave front from the right hits the surface at the middle diamond, and the first wave front from the right hits the surface at the right diamond.

The short-dash concentric circles show that surface has radiated the same-wavelength light from the left diamond.
The medium-dash concentric circles show that surface has radiated the same-wavelength light from the middle diamond.
The long-dash concentric circles show that surface has radiated the same-wavelength light from the right diamond.

The first long-dash circle intersects the first medium-dash circle and the first short-dash circle at the same point.
The second long-dash circle intersects the second medium-dash circle and the second short-dash circle at the same point.
The third long-dash circle intersects the third medium-dash circle and the third short-dash circle at the same point.

No other points show intersection.

The left arrow shows incoming light perpendicular to the wave front.
The right arrow shows outgoing light, perpendicular to the wave front made by the sum of the wavelets.

The incoming and outgoing light rays enter and leave at the same angle.

6>Economics>Macroeconomics>Economic Cycle
economic cycle

6/Economics/Macroeconomics/Economic Cycle/economic cycle.html

Figure 1

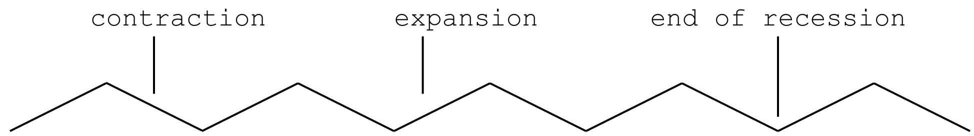


Figure 2

shorter period (and same amplitude)

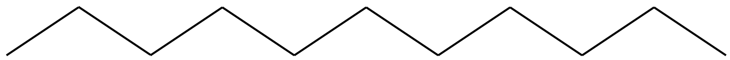


Figure 3

higher amplitude (and same period)

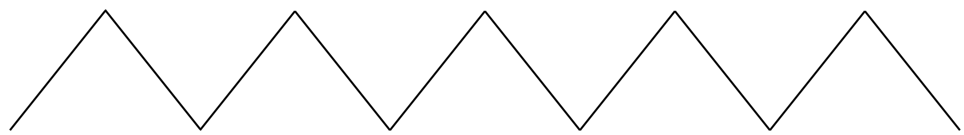
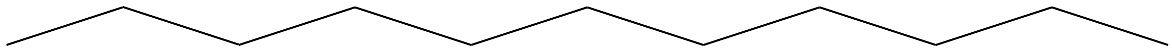


Figure 4

lower amplitude and lower period



6>Economics>Macroeconomics>Fiscal Policy
fiscal policy

6/Economics/Macroeconomics/Fiscal Policy/fiscal policy.html

Figure 1

Normal government spending and taxation
Normal people spending and saving

Government Spend	Government People Tax	People Spend	People Save	
1	1	1111111	1	Normal demand

Figure 2

low tax rate
Government spends same and taxes more
People spend less and save same

Government Spend	Government People Tax	People Spend	People Save	
1	0	11111111	1	Higher demand

Figure 3

high tax rate
Government spends same and taxes more
People spend less and save same

Government Spend	Government People Tax	People Spend	People Save	
1	11	111111	1	Lower demand

Figure 4

low government spending
Government spends less and taxes same
People spend same and save same

Government Spend	Government People Tax	People Spend	People Save	
0	1	1111111	1	Lower demand

Figure 5

high government spending
Government spends more and taxes same
People spend same and save same

Government Spend	Government People Tax	People Spend	People Save	
11	1	1111111	1	Higher demand

Figure 6

low tax rate and low government spending
Government spends same and taxes more
People spend less and save same

Government Spend	Government People Tax	People Spend	People Save	
0	0	11111111	1	Normal demand

Figure 7

high tax rate and low government spending
Government spends same and taxes more
People spend less and save same

Government Spend	Government People Tax	People Spend	People Save	
0	11	111111	1	Much lower demand

Figure 8

low tax rate and high government spending
Government spends less and taxes same
People spend same and save same

Government Spend	Government People Tax	People Spend	People Save	
11	0	11111111	1	Much higher demand

Figure 9

high tax rate and high government spending
Government spends more and taxes same
People spend same and save same

Government Spend	Government People Tax	People Spend	People Save	
11	11	111111	1	Higher demand

6>Economics>Macroeconomics>International Trade comparative advantage

6/Economics/Macroeconomics/International Trade/comparative advantage.html

Figure 1

Country 1 more productive than Country 2 in Product B
Country 2 more productive than Country 1 in Product A
Country 1 more productive in Product B than Product A
Country 2 more productive in Product A than Product B

No Trade

	Country 1	Country 2	Total
Product A	4 (1:3)	6 (3:1)	10
Product B	12 (3:1)	2 (1:3)	14
Total	16	8	24

Trade with Absolute Advantage, Complete Specialization

	Country 1	Country 2	Total
Product A	0	12	12
Product B	24	0	24
Total	24	12	36

Trade with Absolute Advantage, Partial Specialization

	Country 1	Country 2	Total
Product A	2	9	11
Product B	18	1	19
Total	20	10	30

Trade with Opposite of Absolute Advantage

	Country 1	Country 2	Total
Product A	8	0	8
Product B	0	4	4
Total	8	4	12

Figure 2

Country 1 cheaper than Country 2 in Product A
Country 2 cheaper than Country 1 in Product B
Country 1 cheaper in Product A than Product B
Country 2 cheaper in Product B than Product A
Each country has production units whose total cost = 60.
Total production unit cost for both countries = 120.

	Country 1	Country 2
Cost of Product A	4	6
Cost of Product B	5	3

Trade with Absolute Advantage, Complete Specialization
Total Cost = 15*4 + 20*3 = 60 + 60 = 120, with 35 made, the most.

Trade with Absolute Advantage, Partial Specialization
Other Cost = 5*4 + 8*5 + 6*6 + 8*3 = 60 + 60 = 120, with 27 made.

Trade with Absolute Advantage, Partial Specialization
Other Cost = 15*4 + 0*5 + 6*6 + 12*3 = 60 + 60 = 120, with 33 made.

Trade with Opposite of Absolute Advantage
Other Cost = 12*5 + 10*6 = 60 + 60 = 120, with 22 made.

Figure 3

Country 1 cheaper than Country 2 in Product A
Country 2 cheaper than Country 1 in Product B
Country 1 cheaper in Product B than Product A
Country 2 cheaper in Product B than Product A
Each country has production units whose total cost = 60.
Total production unit cost for both countries = 120.

	Country 1	Country 2
Cost of Product A	5	6
Cost of Product B	4	3

Trade with Absolute Advantage, Complete Specialization
Total Cost = 12*5 + 20*3 = 60 + 60 = 120, with 32 made, the most.

Trade with Absolute Advantage, Partial Specialization
Other Cost = 5*4 + 8*5 + 6*6 + 8*3 = 60 + 60 = 120, with 27 made.

Trade with Absolute Advantage, Partial Specialization
Other Cost = 10*4 + 4*5 + 6*6 + 12*3 = 60 + 60 = 120, with 32 made.

Trade with Opposite of Absolute Advantage
Other Cost = 15*4 + 10*6 = 60 + 60 = 120, with 25 made.

Figure 4

Country 1 much more productive than Country 2 in Product B
Country 1 somewhat more productive than Country 2 in Product A
Country 1 more productive in Product B than Product A
Country 2 more productive in Product A than Product B

No Trade

	Country 1	Country 2	Total
Product A	6 (1:2)	4 (2:1)	10
Product B	12 (2:1)	2 (1:2)	14
Total	18	6	24

Trade with Comparative Advantage, Complete Specialization

	Country 1	Country 2	Total
Product A	0	8	8
Product B	24	0	24
Total	24	8	32

Trade with Comparative Advantage, Partial Specialization

	Country 1	Country 2	Total
Product A	3	6	9
Product B	18	1	19
Total	21	7	28

Trade with Opposite of Comparative Advantage

	Country 1	Country 2	Total
Product A	12	0	12
Product B	0	4	4
Total	12	4	16

Figure 5

Country 2 somewhat cheaper than Country 1 in Product A
Country 2 much cheaper than Country 1 in Product B
Country 1 cheaper in Product A than Product B
Country 2 cheaper in Product B than Product A
Each country has production units whose total cost = 60.
Total production unit cost for both countries = 120.

	Country 1	Country 2
Cost of Product A	5	4
Cost of Product B	6	3

Trade with Comparative Advantage, Complete Specialization
Total Cost = 12*5 + 20*3 = 60 + 60 = 120, with 32 made, the most.

Trade with Comparative Advantage, Partial Specialization
Other Cost = 5*6 + 6*5 + 6*4 + 12*3 = 60 + 60 = 120, with 29 made.

Trade with Comparative Advantage, Partial Specialization
Other Cost = 10*6 + 0*5 + 12*4 + 4*3 = 60 + 60 = 120, with 26 made.

Trade with Opposite of Comparative Advantage
Other Cost = 10*6 + 15*4 = 60 + 60 = 120, with 25 made.

Figure 6

Country 1 much more productive than Country 2 in Product A
Country 1 somewhat more productive than Country 2 in Product B
Country 1 more productive in Product A than Product B
Country 2 more productive in Product A than Product B

No Trade

	Country 1	Country 2	Total
Product A	12 (2:1)	4 (2:1)	16
Product B	6 (1:2)	2 (1:2)	8
Total	18	6	24

Trade with Comparative Advantage, Complete Specialization

	Country 1	Country 2	Total
Product A	24	0	24
Product B	0	4	4
Total	24	4	28

Trade with Comparative Advantage, Partial Specialization

	Country 1	Country 2	Total
Product A	18	2	20
Product B	3	3	6
Total	21	5	26

Trade with Opposite of Comparative Advantage

	Country 1	Country 2	Total
Product A	0	8	8
Product B	12	0	12
Total	12	8	20

Figure 7

Country 2 somewhat cheaper than Country 1 in Product A
Country 2 somewhat cheaper than Country 1 in Product B
Country 1 cheaper in Product B than Product A
Country 2 cheaper in Product B than Product A
Each country has production units whose total cost = 60.
Total production unit cost for both countries = 120.

	Country 1	Country 2
Cost of Product A	6	4
Cost of Product B	5	3

Trade with Comparative Advantage, Complete Specialization
Total Cost = 10*6 + 20*3 = 60 + 60 = 120, with 30 made, the most.

Trade with Comparative Advantage, Partial Specialization
Other Cost = 5*6 + 6*5 + 6*4 + 12*3 = 60 + 60 = 120, with 29 made.

Trade with Comparative Advantage, Partial Specialization
Other Cost = 10*6 + 0*5 + 12*4 + 4*3 = 60 + 60 = 120, with 26 made.

Trade with Opposite of Comparative Advantage
Other Cost = 12*5 + 15*4 = 60 + 60 = 120, with 27 made.

Figure 8
Country 2 takes much less time than Country 1 to do or make Product X
Country 2 takes somewhat less time than Country 1 to do or make Product Y
Country 1 takes less time to do or make Product Y than Product X
Country 2 takes less time to do or make Product Y than Product X

Each country has 12 units of time.

	Country 1	Country 2
Product X Time Units	12 (2:1)	4 (2:1)
Product Y Time Units	6 (1:2)	2 (1:2)

Trade with Comparative Advantage, Complete Specialization
Total = 12/12 + 12/2 = 1 + 6 = 7, the most.

Trade with Comparative Advantage, Partial Specialization
Other = 6/12 + 6/6 + 6/4 + 6/2 = 0.5 + 1 + 1.5 + 3 = 6.

Trade with Comparative Advantage, Partial Specialization
Other = 8/12 + 4/6 + 8/4 + 4/2 = 0.67 + 0.67 + 2 + 2 = 5.33.

Trade with Opposite of Comparative Advantage
Other = 12/6 + 12/4 = 2 + 3 = 5.

6>Economics>Macroeconomics>Monetary Policy
monetary policy

6/Economics/Macroeconomics/Monetary Policy/monetary policy.html

Figure 1

Money supply, interest rates, bond selling, discount rate, and reserve ratio are normal.
Normal government spending and taxing
Normal people spending and saving

Government Spend	Government People Tax	People Spend	People Save	
1	1	1111111	1	Normal demand

Figure 2

low interest rate and increased money supply
Normal government spending and taxing
People spend more and save less

Government Spend	Government People Tax	People Spend	People Save	
1	1	11111111	0	Higher demand

Figure 3

high interest rate and decreased money supply
Normal government spending and taxing
People spend less and save more

Government Spend	Government People Tax	People Spend	People Save	
1	1	111111	11	Lower demand

6>Economics>Macroeconomics>Monetary Policy
multiplier effect of money

6/Economics/Macroeconomics/Monetary Policy/multiplier effect of money.html

Figure 1

Marginal propensity to spend is 9/10.

```
  Money increase is 10.0 (1111111111)

  1st person spends  9.0 (111111111)  and saves 1.0.
  2nd person spends  8.1 (11111111)   and saves 0.9.
  3rd person spends  7.2 (1111111)    and saves 0.8.
  4th person spends  6.3 (111111)     and saves 0.7.
  5th person spends  5.4 (11111)      and saves 0.6.
  6th person spends  4.5 (1111)       and saves 0.5.
  7th person spends  3.6 (111)        and saves 0.4.
  8th person spends  2.7 (11)         and saves 0.3.
  9th person spends  1.8 (1)          and saves 0.2.
 10th person spends  0.9 (0)          and saves 0.1.
```

Transaction velocity ~ 10.
Multiplier is 9.

6>Economics>Microeconomics>Supply And Demand
price

6/Economics/Microeconomics/Supply And Demand/price.html

Figure 1

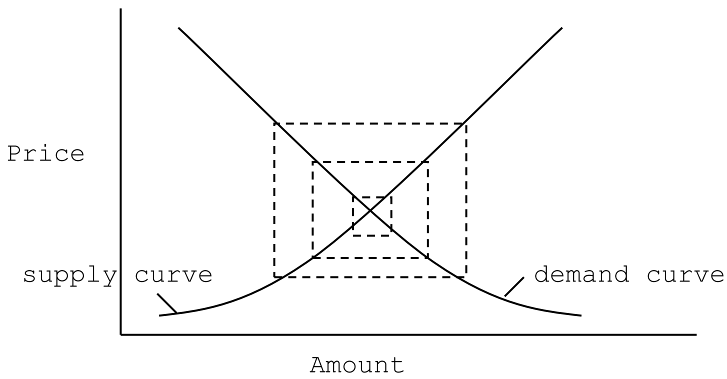


Figure 2

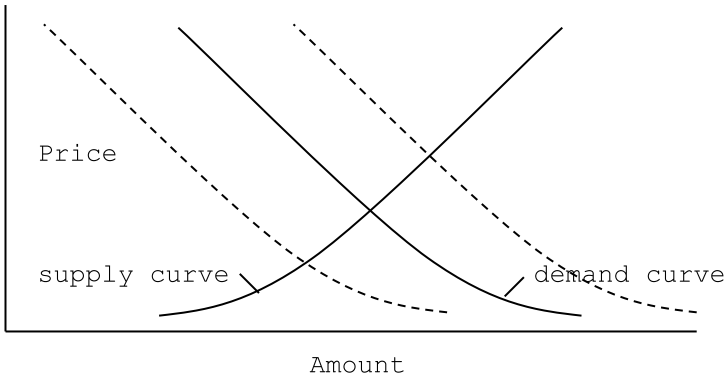


Figure 3