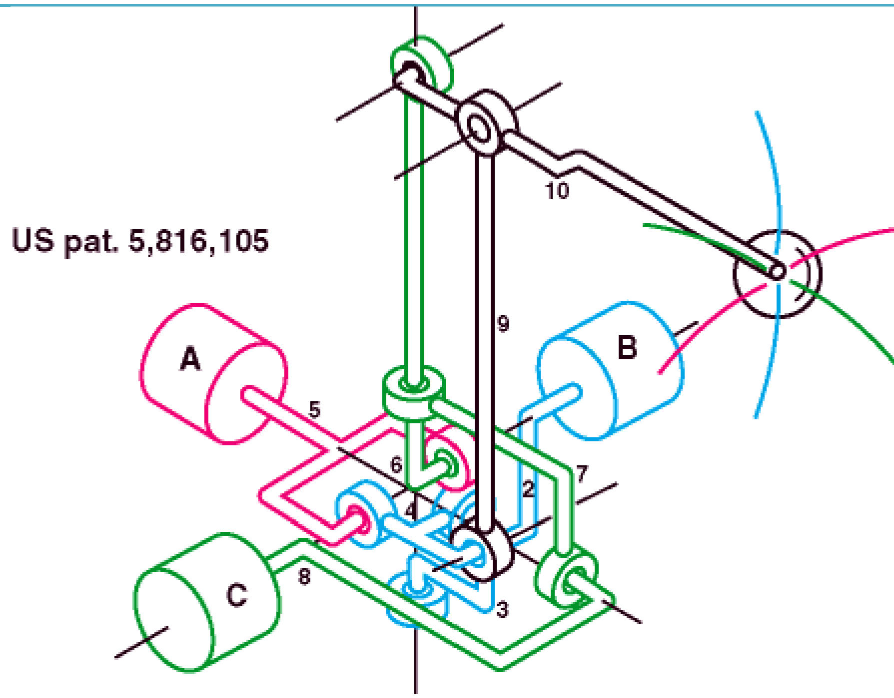
Elizabeth B Torres -Rutgers Psychology

Integrative Methods in Perceptual Science Fall 2011 –Weeks 1-3

Glossary: Here are some useful terms and possible descriptions that we will be using in class, some info from Wikipedia; other from YouTube and other are “home made”

Kinematics	Kinematics (from Greek κινεῖν, *kinein*, to move) is the branch of classical mechanics that describes the motion of bodies (objects) and systems (groups of objects) without consideration of the forces that cause the motion. *Kinematics* is not to be confused with another branch of classical mechanics: analytical dynamics (the study of the relationship between the motion of objects and its causes), sometimes subdivided into *kinetics* (the study of the relation between external forces and motion) and *statics* (the study of the relations in a system at equilibrium). *Kinematics* also differs from *dynamics* as used in modern-day physics to describe time-evolution of a system. The term *kinematics* is less common today than in the past, but still has a role in physics. The term *kinematics* also finds use in biomechanics and animal locomotion. The simplest application of kinematics is for particle motion, ***translational or rotational***. The next level of complexity comes from the introduction of rigid bodies, which are collections of particles having time invariant distances between themselves. Rigid bodies might undergo translation and rotation or a combination of both. A more complicated case is the kinematics of a *system* of rigid bodies, which may be linked together by mechanical joints. Kinematics can be used to find the possible range of motion for a given mechanism, or, working in reverse, can be used to design a mechanism that has a desired range of motion. The movement of a crane and the oscillations of a piston in an engine are both simple kinematic systems. The crane is a type of open kinematic chain, while the piston is part of a closed four-bar linkage.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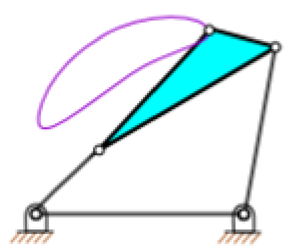
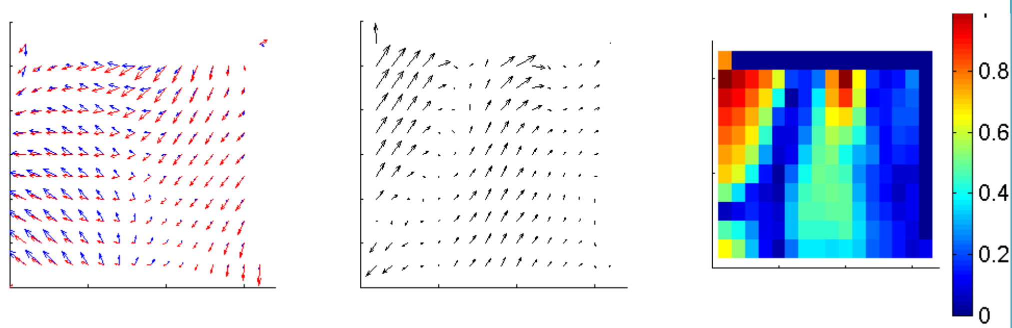


Dynamics	In the field of physics, the study of the causes of motion and changes in motion is **dynamics**. In other words the study of forces and why objects are in motion. *Dynamics* includes the study of the effect of torques on motion. These are in contrast to kinematics, the branch of classical mechanics that describes the motion of objects without consideration of the causes leading to the motion. Generally speaking, researchers involved in dynamics study how a physical system might develop or alter over time and study the causes of those changes. In addition, Isaac Newton established the undergirding physical laws which govern dynamics in physics. By studying his system of mechanics, dynamics can be understood. In particular dynamics is mostly related to Newton's second law of motion. However, all three laws of motion are taken into consideration, because these are interrelated in any given observation or experiment. For classical electromagnetism, it is Maxwell's equations that describe the dynamics. And the dynamics of classical systems involving both mechanics and electromagnetism are described by the combination of Newton's laws, Maxwell's equations, and the Lorentz force.
Vector	http://www.youtube.com/watch?v=xJBGfPfE4fQ&feature=related Euclidean vector, a geometric entity endowed with both length and direction; an element of a Euclidean vector space. In physics, Euclidean vectors are used to represent physical quantities which have both magnitude and direction, such as force, in contrast to scalar quantities, which have no direction.  Vector Fields from neural activities (cell in the intra Parietal sulcus of rhesus macaques) Preferred Direction rotated across space and scalar map of the magnitude of the differences in these vector fields obtained using the Lie Bracket (Commutator) Operator which gives the residual in black. Blue are from sampled locations in the frontal plane where the hand reaches straight and red is the planning of the same cell as the hand curves around obstacles. The Lie Bracket gives the smooth rotations and the color map give the magnitude of the residual vector field taken at each point

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<tr><td>Rigid Body</td><td>
In physics, a rigid body is an idealization of a solid body of finite size in which deformation is neglected. In other words, the distance between any two given points of a rigid body remains constant in time regardless of external forces exerted on it. Even though such an object cannot physically exist due to relativity, objects can normally be assumed to be perfectly rigid if they are not moving near the speed of light.

In classical mechanics a rigid body is usually considered as a continuous mass distribution, while in quantum mechanics a rigid body is usually thought of as a collection of point masses. For instance, in quantum mechanics molecules (consisting of the point masses: electrons and nuclei) are often seen as rigid bodies (see classification of molecules as rigid rotors).

The position of a rigid body is determined by the position of its center of mass and by its attitude (at least six parameters in total).

http://www.youtube.com/watch?v=UpSMNYTVqQI&feature=related
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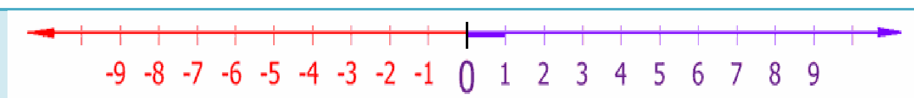
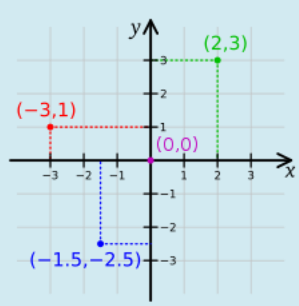
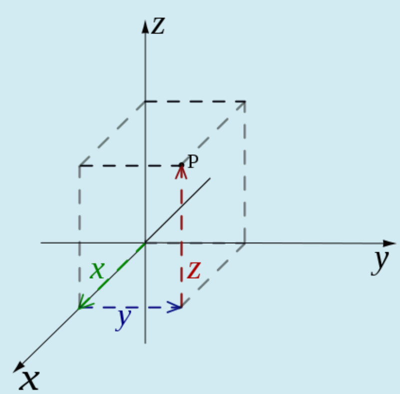
<tr><td>Coordinate systems</td><td>






Cartesian Coordinates (1-; 2-; 3-dimensions)
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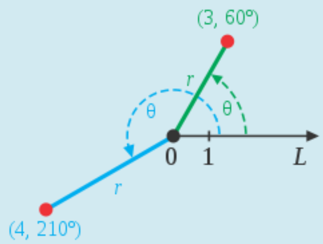
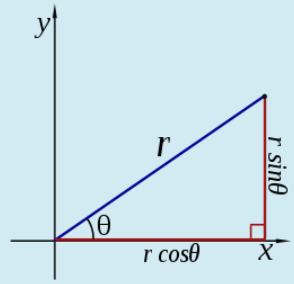
Polar Coordinates





$x = r\cos\theta$

$y = r\sin\theta$

$r = \sqrt{y^2 + x^2}$

$\theta = a\tan 2(y, x)$

http://www.youtube.com/watch?v=a41fOqWFCbI

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Frames of reference

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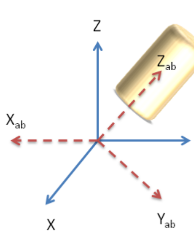
http://www.youtube.com/watch?v=Y75kEf8xLxI

http://www.youtube.com/watch?NR=1&v=dAoGpflOmdw

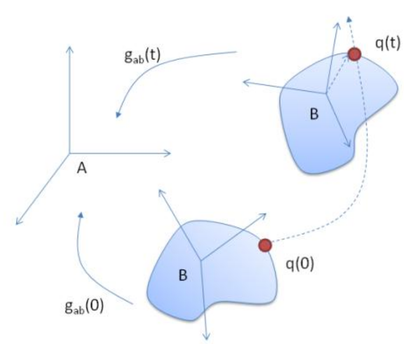
http://www.youtube.com/watch?v=3ug23VTMies&NR=1

http://www.youtube.com/watch?v=GzvGfOgf7Y4&feature=related



$R_{ab} = [X_{ab}, Y_{ab}, Z_{ab}] = \begin{pmatrix} x_{ab}^X & y_{ab}^X & z_{ab}^X \\ x_{ab}^Y & y_{ab}^Y & z_{ab}^Y \\ x_{ab}^Z & y_{ab}^Z & z_{ab}^Z \end{pmatrix}$

ROTATION OF A RIGID OBJECT ABOUT A POINT (DOTTED COORDINATE FRAME IS ATTACHED TO THE RIGID BODY



TRAJECTORY OF A RIGID BODY RELATIVE TO A FIXED FRAME

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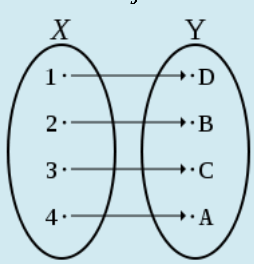
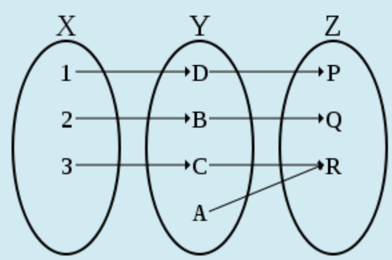
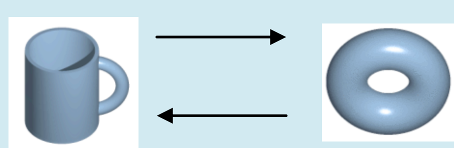
<tr><td>Configuration space</td><td>In classical mechanics, the configuration space is the space of possible positions that a physical system may attain, possibly subject to external constraints. The configuration space of a typical system has the structure of a manifold; for this reason it is also called the configuration manifold.

The configuration space of a rigid body with one point fixed (i.e., a body with zero translational motion) is given by the underlying manifold of the rotation group SO(3).

The configuration space of a nonfixed (with non-zero translational motion) rigid body is $E^{+}(3)$, the subgroup of direct isometries of the Euclidean group in three dimensions (combinations of translations and rotations).</td></tr>
<tr><td>End-effector space</td><td>The space where we track the motions of the hands (or feet). We track their position in time and their orientations in time. We can track the rate of change of position (linear velocity) and the rate of change of rotation (angular velocity)
Likewise if we go to second order, we can track the rates of change of linear velocity (linear acceleration) and the rate of change of angular velocity (angular acceleration) ….and so on</td></tr>
<tr><td>Coordinate Maps and Manifolds</td><td>Let $V \subset R^m$ and $U \subset R^n$ be open sets. A mapping $f: U \rightarrow V$ is a smooth map if all partial derivatives of f, of any order exist and are continuous. If m = n, and f is bijective (a one-to-one correspondence between the elements in the two spaces), and both f and f^{-1} are smooth, then f is called a diffeomorphism and U and V are said to be diffeomorphic

A bijection and a Bijective Composition (a bijection and a surjection)

Domain f Co-Domain

(f is a surjective (onto) function if for every y in Y there is an x in X with f(x)=y

A manifold of dimension n is a set M which is locally homeomorphic to R^n (M is the same as R^n for all practical purposes, e.g. two homeomorphic manifolds are a mug and a torus –a donut- because through a continuous deformation one can go from one to the other).
</td></tr>
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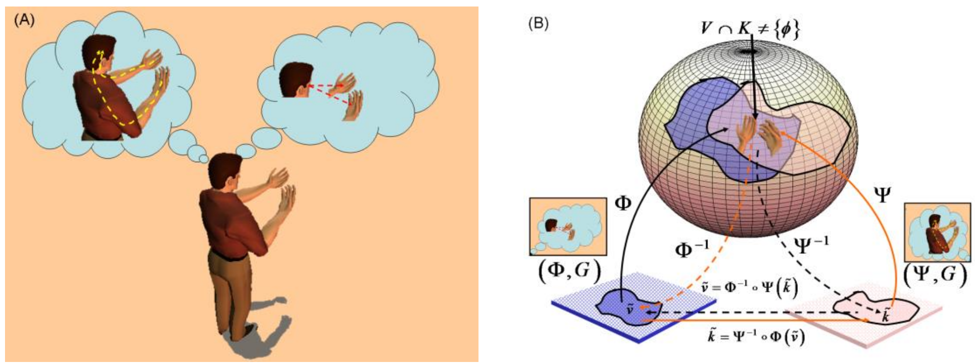
	We parameterize the Manifold by using a set of local coordinate charts. A local coordinate chart is a pair (ϕ, V) where ϕ is a function which maps points in the set $V \subset M$ to an open subset of R^n. Two overlapping charts (ϕ, V) and (φ, K) are smooth (C^∞) related if $\varphi^{-1} \circ \phi$ is a diffeomorphism where it is defined. A collection of such charts with the additional property that V's cover M is called a smooth atlas. A manifold M is a smooth manifold if it admits a smooth atlas.
Examples of Coordinate Charts	Examples of coordinate charts for sensing the hands both visually (V) and kinesthetically (K) and for directly converting from one sensory mode to another  $V \subset M$ and $K \subset N$ with M and N both locally homeomorphic to R^n and with coordinate functions Φ and Ψ
Forward Map	Let *Q* represent the space of joint configurations of dimensions *n*, and *X* represent the space of hand configurations of dimensions *m*, let *f* be some map $f: Q \subset N \rightarrow X \subset M$ that assigns to each *x in X* at least one *q in Q*, then we call *f* the forward map. The dimensions can be n = m, n >>m, etc. The map is usually many-to-one in the case of arm-to-hand or body-to-end effector maps
Inverse Map	Suppose that you want to know, given an *x in X* which one is the corresponding *q in Q*, the inverse map f^{-1} is the function that for any hand configuration gives you a unique configuration of the arm joints. This is an ill-posed problem because there are many configurations of the arm which map onto the same configuration of the hand.