Kinematics and dynamics pdf

A branch of physics describing the movement of objects or groups of objects without considering its cause is Kinematic redirects here. For the Australian band, see Kinematic (group). Part of the series on Classical Mechanics F q d t (m v) displaystyle textbf Ffrac (d'textbf (v)) Second Law of Motion History Timeline Tutorials Applied Celestial Continuum Dynamics Kinematics Kinetics Static Statistical Basics Acceleration Of The Angular Impulse Of Para D'Alem The principle of Energy Kinetic Potential Force Frame links Inertial Frame links Impulse inertia / Moment of inertia Mass Mechanical Power Mechanical Work Momentum Space Speed Time Torque Virtual Wording Newton's Motion Laws Analytical Mechanics Aghantton MechanicsRuthian MechanicsHiton MechanicsHilton-Jacobi equationAppell equation MotionCopman-von Neumann Mechanics Main Themes Damping (Ratio) Moving Equation Motion Euler Laws Motion Fictitious Friction Force Harmonic Oscillator Inertia /Non-Inerator Reference Frame Mechanics Of Planar Particles of Motion (Linear) Newton Law of Universal Gravity Newton's Gravity Laws Movement Relative Speed Of The Body Rigid Dynamics Of Equations Simply Harmonic Motion Vibration Rotation Circular Motion Rotating reference frame Centropetal force Centrifugal force reactive Coriolis force Pendulum Tangential Speed speed Angular acceleration / movement / frequency / speed Scientists Kepler Galileo Guygens Newton Horrocks Halli Daniel Bernoulli Johann Bernulli Euler D'Alembert Clairo Lagrange Laplace Laplas Hamilton Poisson Koshi Ruth Laville Appell Gibbs Kupman von Neumann Category is developed in classical mechanics, which describes the movement of points, bodies (objects) and body systems (groups of objects) without considering the forces that make them move. Kinematics, as an area of study, is often referred to as movement geometry and is sometimes seen as a branch of mathematics. The problem of kinematics begins with describing the geometry of the system and announcing the baseline conditions of any known position, speed, and/or point acceleration in the system. Then, using arguments from geometry, you can determine the position, speed and acceleration of any unknown parts of the system. Studying how forces work on the body refers to kinetics, not kinematics. For more information, see Kinematics used in astrophysics to describe the movement of celestial bodies and collections of such bodies. Geometric transformations, also called rigid transformations, are used to describe the movement of components in a mechanical system, making it easier to deduce motion equations. They are also central to dynamic analysis. Kinematic analysis is the process of measuring the kinematic quantities used to describe movement. In engineering, for example, kinematic analysis can be used to find the range of motion for a given mechanism and works backwards, using kinematic synthesis to develop a mechanism for the desired range of motion. In addition, kinematics uses algebraic geometry to study the mechanical advantage of a mechanical system or mechanism. The etymology of the term Cinematic term is the English version of the A.M. Amper film fiction, which he built from the Greek kinema κίνημα (movement, movement), most derived from the κινεῖν kinein (move). Kinematics and synematics are associated with the French word synema, but neither is directly derived from it. However, they have a common root word, since the synema originated from the shortened shape of the cinematographer, film projector and camera, once again from the Greek word for movement and from the Greek γρᾰ́φω grapho (write). The kinematic trajectory of the particle in the non-rotating frame of the reference kinematic quantities of the classical particle: mass m, position r, speed v, acceleration a. The position of vector r, always indicates radially from origin. Speed vector v, always tangent to the path of movement. The acceleration vector is not parallel to radial movements, but compensated by angular and coriolysive accelerations, as well as tangents on the way, but compensated by centopetal and radial accelerations. Kinematic vectors in flat polar coordinates. Note that the setting is not limited to 2D space, but the plane in any higher dimension. Particle kinematics are the study of the trajectory of particles. The position of the particle is defined as a vector of coordinates from the origin of the coordinate frame to the particle. For example, consider the tower 50 meters south of your house, where the coordinate frame is concentrated at your home, so that the east is in the direction of the x-axis, and the north is in the direction of the axis, then the vector of coordinates to the base of the tower r q (0, 50, 0). If the height of the tower is 50 m, and this height is measured along the axis of z, the vector of coordinates to the top of the tower is r q (0, 50, 50). In the most general case, a three-dimensional coordinate system is used to determine the position of the particle. However, if the particle is limited to move within the plane, a two-dimensional coordinate system is sufficient. All observations in physics are incomplete, without describing the reference framework. The particle position vector is a vector taken from the origin of the link to a particle. It expresses both the distance of the point from origin and its direction from origin. In three dimensions, the position of point P can be expressed as P = (x P , y P , z P) = x P ı ^ + y P ȷ ^ + z P k ^ , {\displaystyle \mathbf {P} =(x_{P},y_{P},z_{P})=x_{P}{\hat {\imath }}+y_{P}{\hat {\jmath }}+z_{P}{\hat {k}},} where x P {\displaystyle x_{P}} , y P {\displaystyle y_{P}} , and z P {\displaystyle z_{P}} are the Cartesian coordinates and ı ^ {\displaystyle {\hat {\imath }}} , ȷ ^ {\displaystyle {\hat {\jmath }}} and k ^ {\displaystyle {\hat {k}}} are the unit vectors along the x {\displaystyle x} , y {\displaystyle y} , and z {\displaystyle z} coordinate axes, respectively. The position of the Left mathuf (right) vector (right) gives the distance between the P display (mathbf) and the origin. | P x P 2 y 2 and z P 2. Display-styleMatebf (P) Sqrt x_ P 2 y_ P 2 z_ P 2 . The direction of the position vector cosins provides a quantitative measurement of direction. It is important to note that the particle position vector is not unique. The position vector of this particle differs from the different frames of the countdown. The particle trajectory is a vector function of time, P (t) mathbf (t) display, which detects a curve traces by a moving particle, given p (t) x P (t) y P (t x_) ȷ z P (t) k, display mathbf P (t) hat imath y_p (t) hat jmath z_ P (t) hat k where the coordinates of xP, yP and zP are the functions. The distance traveled is always greater or equal to moving. The speed and speed of a particle speed is a vector amount that describes the magnitude as well as the direction of the particle' movement. More mathematically, the rate of change is the vector position of the point, relative to the time of the speed point. Let's consider the ratio formed by dividing the difference between the two particle positions at the time interval. This ratio is called average speed during this time period and is defined as the speed of movement/time taken by V¯- P t , display style overline mathbf V (B) Frak Delta Mattf Delta T where P is a change in the vector position over a period of time. In the limit, as the time interval gets smaller and smaller, the average speed becomes a derivative of position vector time, V x lim t → 0 ˙ȷ ¨0 x. Display style matebf Lim Delta t'rightarrow 0 frac Delta Mattp Delta tFrak (d'mathbf) (pj) (point) (x-hep) hat (imath) dot (y)P'hat (jmath) So the speed the rate of change in the position of the point, and the point denotes a derivative of these functions x, y, and z in relation to time. In addition, the speed on the tangent on the particle trajectory in each position of the particle occupies along its path. Note that in a non-rotating framed frame, the derivatives of the coordinates are not considered as their directions and the magnitudes are constants. The speed of an object is the magnitude of its speed. It's a scalable amount: B. ˙d s d t , display style (mathematics) dot mathbf P (P) frac (ds'dt), where s is the length of an arc measured by the trajectory of the particle. This arc length, traveled by a particle over time, is not decreasing in quantity. Thus, ds/dt is not negative, which means that the speed is also not negative. Accelerating Vector speeds can vary in size and direction or as soon as it is. Thus, the acceleration is explained both by the speed at which the speed of the vector changes and by the speed at which the direction of the vector changes. The same reasoning used for particle position to determine velocity can be applied to speed to determine acceleration. Particle acceleration is a vector determined by the speed at which the velocity vector changes. The average acceleration of a particle over a period of time is defined as a ratio.¯- V t, display style offline math A Frak Delta Matebf (B) , Delta T where V. V. is the difference in the vector of speed, and it is the interval of time. Particle acceleration is the limit of average acceleration as the time interval approaches zero, which is a derivative of time, A-lim-t-→ 0 x x 0 x t- d t t ˙- v ˙x x ˙y ȷ y v ˙z k Frak DeltaMuff (B) Delta tFrac d'Matebf B (B) dt dot matebf (V) Hat (jmath) - dot (viac) or A. imath ȷ ddot yP -hat (jmath) acceleration is the first derivative of the velocity vector and the second derivative of the position of this particle. Note that in a non-rotating framed frame, the derivatives of the coordinates are not considered as their directions and the magnitudes are constants. The magnitude of the object's acceleration is the magnitude of the acceleration vector. It's a scalable amount: A V ˙d v d t , mathbf display mathbf point v frac (dv'dt), Relative position vector Relative position vector is a vector that determines the position of one point relative to another. It is difference in position of two points. The position of one point A relative to another point B is simply the difference between their P A/B - P - P - P B (display) (P) (P) (P) (P) /B'mathbf (P) positions - the difference between the components of their position vectors. If there are components of position P A (X A, Y A, A) (display style (mathbf (P) (left) (X_.A., Y_,Z_) if point B has components of position P B (X B, Y B, B) display matbf P (BB left) X_ then the position of point A relative to point B, Y_BZ, Z_ B on the right) the position of point A relative to point B is the difference between their component issues: P A / B - P A - P B (X A - X B, Y A - Y B, A - B) left (X_ -A-X_,Y_-A-Y_,Z_-A-Z_ B-right) Relative speed Main article: Relative speed Relative speeds between two particles in classical mechanics. to the other, it's just the difference between their speeds V A/B - V A - V B (display) (V) (V) (B) (B) (A/B' mathbf) ( ) - it's the difference between the components of their speeds. , V A y, V A z) (display style (matebaf)WA on the left (V_A_ x.V_,A_,V_ A_sopravity) and point B has components of speed V B (V B x, V B y, V B z) display mathbf V (B) (V_ B_V_B_ y's) (V_ B_V_B_'s) V_ 'B_'z'z's'right) , the speed of point A relative to point B is the difference between their components: V A/B v B z) 'display style' matbf B (B) WA/BMatebf (B)-Matebf (B) (B) left (V_A_ x-V_. B_hhk. V_ A_-V_ B_.V_-A_-V_ B_) As an alternative, the same result can be obtained by calculating the derivative time of the RB/A relative position vector. If the speed is close to the speed of light C (usually within 95%), in a special theory of relative speed called speed, which depends on the ratio of V to C, another relativity is used. A C/B - A C - A B (display) (mathbf) (A) (C/B) mathbf (A) (C)-Mathbf (A) - is the difference between the components of their accelerations. If point C has acceleration components A C (A C x, A C y, A C z) (display style (mathbf) (A) (left) (A_ C_), A_ C_ (C_.A_ C_) and point B has acceleration components A B q (A B x, A B y, A B z) display mathbf (left) (A_ B_.A_.B_.A_B_ Right) , then the acceleration of point C relative to point B is the difference between their components: A C/B - A C - A B x, A C y - A B y, A C C, A C A B z) display style matbf A (A) C/B mathbf (A) C-Mathbf (A) (A_C_A_B_A_ C_ A_ Alternatively, the same result could be obtained by calculating the second derivative of the relative position vector B_ PB/A'13, A_-B_.y., C_ A_-z'-A_. Assuming that the original terms of the provision, P 0 display (p) {0} and speed V 0 displaystyle (V) {0} during t 0 displaystyle t0 are known, the first integration gives particle speed as a function of time. V (t) - V 0 and ∫ 0 t a v v 0, etc. Display-style matebf B (t) matebf (B) B (B) {0} int ({0}) t'mathbf (A) d'tau mathbf V ({0}) matebf (A) t. Second integration gives its way (trajectory), P (t) - P 0 - ∫ t. ∫ . . . . Display-style matebf P (t) Matebf (P) P ({0})int ({0})MatebF (B) (Tau) Dzatau Matebf P ({0}) int ({0}) ({0}) (Matebf ({0}) (Matebf ({0}) ({0}) ({0}) ({0}) ({0}) ({0}) ({0}) ({0}) ({0}) C) {0}-matebf (AAU) Atau (mateb)Matebf (P) ({0})Matebf (B) {0}thfrack {1}{2}matbf (A) t'{2}.) Additional relationship between movement, speed, acceleration and time can be obtained. Since acceleration is constant, A - V - V - V - V (display) (mathbf) {0} - frak (Delta) (Delta) (Delta) (G) Display-style matebf P (t) Matebf (p) {0} left (frak matebf {2} {0} (In) solving average acceleration for time and replacing and simplifying t - V V V 0 A displaystyle t frac (mathbf) ∘ ∘ --mathbf {0} (V) 2 , display style (Mat Ebf (P) - Matebf (P) (P) (P) {0}) Circle 'Matebf' A on the left (Matebf (G) - Matebf (G) {0} ∘ {2} {0} (right) because the products are scalars, not vectors. 2 (P - P 0) ∘ A V 2 - V 0 2 . Displaystyle 2 (Matthewff (P) {0} - Mattbf (P) (P) Circle Matthew A Matebf (B) {2}-Mattff (B) {0} {2}. The point can be replaced by a cosine angle α between vectors (citation is necessary) and vectors of their magnitudes, in this case: 2 P- P 0 · A · cos α w 2 - V 0 2 . Display Style 2 math (P) - Mateb P (P) {0} -Kdot Matebf Matbf MatbF A Kdot com Alpha Matbf (B) {2}-Matebf (B) {0} {2}. In the case of acceleration always in the direction of movement and direction of movement should be positive or negative, the angle between vectors (α) is 0, so cos 0 1 display (cos 0'1) , and B. 2 th v 0 2 to 2 euros A · P P 0. Display-styleMatebf (B) {2} Mateff (B) B ({0}){2}2 ({0} A) This can be simplified by notation for the magnitude of vectors A. A. I'm not sure that it is. B. v, P- P 0 - x display (math) For, (matthew) z, Mathbf P - Mathbf P ({0}) Delta x (quote is necessary) where the x display Delta x can be any lush way taken as a permanent tangent acceleration applied along this path, so v 2 v 0 2 2 a · x. Display style v'{2} v_{0} {2} 2a'cdot Delta x. This reduces the parametric equations of particle motion to the cartise relationship of velocity with position. This attitude is helpful when time is unknown. We also know that x x x ∫ v d display (Delta x'int v',dt) or x display (Delta x) is an area under v, t graph. Speed time physics graph We can take x display (Delta x), adding the upper area and the lower area. The lower area is a rectangle and the rectangle area is A · B (A'cdot B display), where A is displaystyle A and the height is B (displaystyle B). In this case, A t (display A't) and B v 0 (displaystyle B'v_{0}) (note that A 'displaystyle A) is different here from the displaystyle a acceleration). This means that the lower area t v 0 display tv_{0}. Now let's find the top area (triangle). The transistor area is 1 2 B H (display) (frac {1}{2}) BH, where the base is B (displaystyle B), and H (displaystyle H) is height. In this case, B t (display B'T) - H - T (display H'at) or A 1 2 B H - 1 t t 1 2 t 1 2 a t 2 t 2 - t 2 t 2 (display) Style A.Frak {1}{2}BHA FRAK {1}{2}t'frak {1}{2}ata {2} frac (on {2} {2}). Добавление t v 0 «displaystyle tv_{0}» и t 2 2 «дисплей» (frac){2} {2}) приводит к уравнению x «дисплей» (Дельта) x', приводит к уравнению x x x 0 т й т 2 2 «дисплей» (Дельта x'v_{0}t'frac (at'{2}){2}). This equation is very useful when the final speed v is unknown. Figure 2: Speed and acceleration for non-ununiform circular movements: tangential speed vector to orbit, but the acceleration vector is not radially inward due to its tangent component aθ which increases the speed of rotation: d aθ'/dt Trajectories in cylinico-polar coordinates See also: generalized coordinates, Chirinovsky coordinates, orthogonal coordinates and Frenet-Serret formulas Are often convenient to formulate the trajectory of the P/t particle - (X(t), Y (t) and q (t)) using polar coordinates in the X-Y plane. At the same time, its speed and acceleration take a comfortable form. Recall that the trajectory of the P particle is determined by its P-rate vector, measured in a fixed кадр Φ. По мере движения частицы вектор координат P(t) отслеживает свою траекторию, которая представляет если это кривая в пространстве, то есть: P (t) ȷ - X (t) j, и k являются векторами единицы вдоль осей X, Y и q эталонного кадра F Соответственно. Рассмотрим частицу P, которая движется только по поверхности кругового цилиндра R(t) Постоянная, можно выровнять ось й фиксированной рамы F с оси цилиндра. Затем угол θ вокруг этой оси в плоскости X-Y может быть использован для определения траектории, как, P (t) - R cos θ (t ȷ θ) . «Дисплей-стиль »текстбф »Пя(т)»Pё кос (т) »шляпа »imath »R»sin (t) »шляпа »jmath »(t) шляпа «k». Цилиндрические координаты для P (t) могут быть упрощены путем введения радиальных и касательных векторов единицы, e r - cos θ (t) - грех θ (t) ȷ , e θ - грех θ (t) - cos θ (t) ȷ . . «Дисплейстайл »текстбф »э-р»кос (т)»шляпа «imath» (грех) «текстбфф» »э-такита»-грех (т) »шляпа »imath » cos «theta (t)» шляпа «jmath». и их производные времени от элементарного исчисления: d d t e r e r и θ e θ «дисплей »frac »d'dt»textbf точка «текстбфф» (e'r'r'dot) «theta» (текстбф) (e'theta) d d t e r e r и θ e θ θ e r (дисплей) «фрак »ддт» точка «текстбф» «Дддот»тета,текстбф (e'theta) - точка (точка) (theta) текстбф (e'r) d d t e θ e θ - θ e r (дисплей) (фрак дт) текстбф (e'theta) точка (текстбф) тья-точка (точка) - текстбф (e'r' d d t e θ e θ) - θ e r - θ 2 e θ «дисплей »фрак »ддт» точка «текстбф» (e'theta) »ddot »текстбф »e»theta «Дддот »тьота»текстбф (э-р-точка) »тьота »{2}»текстбф (e'theta) . Используя эту нотацию, P (t) принимает форму, P (t) - R e r q (t) k , displaystyle textbf (P)(t)R'textbf (e'r)(t) ,hat (k),, где R является постоянным в случае частицы, перемещаемой только по поверхности цилиндра R. В общем, траектория P(t) не ограничена, чтобы лежать на круговом цилиндре, так что радиус R изменяется со временем и траектория частицы в цилиндрико-полярных координатах становится : P (t) r (t) e r q (t) k . «Дисплейстайл »текстбф (ПЗ(т)»P(т)»Текстбф (э-р) (т) Там, где R, theta, и q могут быть непрерывно по-разному функции времени и функция нотации упал для простоты. The velocity vector VP is the time derivative of the trajectory P(t), which yields: V P = d d t (R e r + Z k ^) = R ˙e r + R e ˙r + Z ˙k ^ = R ˙e r + R θ e θ + Z κ.3. Displaystyle (текстбф)Ве-Пяпя-фрак (ддт) (Рётембф (Эр-Рёрдхет) Точка (точка) (R'textbf) (e'R'dot) (theta) textbf (e'theta) . Аналогичным образом, ускорение AP, которое является производной времени от скорости VP, дается: P q d d t (R ˙e r r r θ e θ q k) (R - R θ 2) e r (R θ 2 R θ) e θ . «Дисплейстайл »текстбф »А»П»Фрак (д'дт) (точка «R»textbf (эр-текстбф) Рё-Рёдот {2} (Рддот, Фета) »2»2-точка «Рёта» (РДДОТ,2) Термин «R θ 2 e r» (дисплей) «R»dot (точка) {2} «текстбф» (e'r) действует в сторону центра кривизны пути в этот момент на пути, обычно называют центроемонным ускорением. Термин 2 R θ e θ «дисплей 2» точка «точка» (точка) «theta» textbf (e'theta) называется ускорением Кориолиса. Постоянный радиус Если траектория частицы ограничена лежать на цилиндре , то радиус R является постоянным и векторы скорости и ускорения упрощаются. The velocity of VP is the time derivative of the trajectory P(t), V P = d d t (R e r + Z k ^) = R θ e θ + Z k ^ . «Дисплейстайл »текстбф »Ве»Пяп»Фрак (РДДТ) (Рётембф (Эр-е-хе-шляпа(к) Вектором ускорения становится: P-d d t (R θ e θ - k) - R θ 2 e r r θ e θ. «Дисплейстайл »текстбф (А.П.) фрак (РДДТ)-шляпа (к)--Рёту (Ата) {2}-текстбф (Эро)Рёддот (тета) текстбф (ээхта) Здот (шляпа) Планарные круговые траектории Каждая частица на колесе движется по планарной круговой траектории (Kinematics of Machinery , 1876). Особый случай траектории частицы на круговом цилиндре возникает, когда нет движения по оси: P (t) , R e r й 0 k , «displaystyle »textbf (P)(t)»R»textbf (e'r'Z_{0}'hat , где R и No0 являются константами. В этом случае вице-президент по скорости дается: V P q d d t (R e r й 0 k) - R θ e θ r q e θ , Displaystyle (текстбф) (ВЕП) «Z_{0}»шляпа (к) » Рёта (такта) « текстбф», «Эхатета» (Рехома) «текстбф» (e)theta, где No θ , «displaystyle »omega» (омега-точка) , — это угловая скорость вектора блока, eθ вокруг оси z цилиндра. Ускорение AP частицы P теперь дается: P q d d t (R θ e θ) - R θ 2 e r и R θ e θ . «Дисплейстайл »текстбф (А.П.) Фрак (Рдт) (Рёт (Ата-текстбф)»-Рёт(Атата) (e) Ero-Roeddot (teta) textbf (ehta) Components a r q R θ 2, a θ and R θ , displaystyle a_r'-R'-dot (theta) {2}, four a_ the R -t Notation for angular speed and angular acceleration is often defined as no θ , α and θ, omega point display, tact and four alpha-ddot (theta), so the radial and tangent acceleration components for circular trajectories are also written as r - R q 2, a θ and R α. Display style a_-Ryomia {2}, four-seater a_ AtaRyo Alpha. Point trajectories in the hull moving in a plane are analyzed by the movements of the components of the mechanical system by attaching the reference frame to each part and determining how the different reference frames move relative to each other. If the structural rigidity of the parts is sufficient, their deformation can be neglected and rigid transformations can be used to determine this relative movement. This reduces the description of the movement of different parts of a complex mechanical system to the problem of describing the geometry of each detail and the geometric connection of each part in relation to other parts. Geometry is the study of the properties of shapes that remain the same, while space is transformed in different ways - more technically, it is the study of ivarants within a set of transformations. These transformations can cause the triangle to shift in the plane, leaving the angle of the top and the distance between the verticals unchanged. Kinematics is often described as applied geometry, where the movement of a mechanical system is described using the rigid transformations of Euclidean geometry. The coordinates of the points in the plane are two-dimensional vectors in R2 (two-dimensional space). Strict conversions are those that keep the distance between any two points. A set of rigid transformations in the n-dimensional space is called a special Euclidean group on Rn and is designated SE (n). The movement and movement of each of the components of the Boulton and Watt steam engine (1784) is modeled by a continuous set of rigid shifts. The position of one component of the mechanical system in relation to another is determined by the introduction of a reference frame, say M, on one that moves relative to a fixed frame, F, on the other. A strict transformation, or shift of M in relation to F, determines the relative position of the two components. Moving consists of a combination of rotation and translation. A set of all M shifts in relation to F is called the M configuration space. set of rotations and translations. A matrix view of the combination of rotation and translation in the R2 plane can be represented by a certain type of 3x3 matrix known as a homogeneous transformation. The 3x3 single-breed transformation is built from the 2x2 A (φ) rotation matrix and the 2x1 d'(dx, dy) translation vector, as: T (φ, d) - a (φ φ) d 0 1 - cos φ - sin φ d sin x φ cos φ d y 0 0 1 . Displaystyle T (THI, Matbf (d) start bmatrix a (Fi) Matebf (d) Kos fi-sin (phi)phi (d_)x'sin (phi)cos (phi) d_ y'0'0'1'end'bmatrix). These homogeneous transformations perform rigid transformations on points in the plane z'1, that is, at points with coordinates of the pH (x, y, 1). In particular, let the p determine the coordinates of the points in the reference frame M coincides with the fixed F frame. Then, when the origin of M is superseded by the translation d vector in relation to the origin of F and rotates at an angle φ relative to the F-axis, the new coordinates in the F points in M are given: P q T (φ φ, d φ φ φ) Displaystyle textbf Pyapchet T (Fi, Matbf (d)) text ,cos (fi)-sin (fi d_) Sin fi phy phy d_ y001endbmatrixbeginning Bmatrixx'y'1'end Bmatrix. Homogeneous transformations are affinous transformations. This formulation is necessary because translation is not a linear R2 transformation. However, using design geometry, so that R2 is considered a subset of R3, translations become affinity linear transformations. Pure translation If the rigid body moves so that its reference frame M does not rotate (∅0) in relation to the fixed frame F, the movement is called pure translation. In this case, the trajectory of each point in the body is a shift in the trajectory d(t) of origin M, i.e.: P (t) - T (t (t) Displaystyle textbff (PP(t) textbf (d'(t) Thus, for bodies in pure translation, the speed and acceleration of each P point in the body are given: V P and P ˙(t) d ˙(t) , V O , A P - P (t) d) Point (textbf (d't) , four textbf (A'P)ddot (textbf) where the point denotes a derivative in relation to time and VO and AO are speed and acceleration, respectively, the origin of moving frames M. Recall that the vector of coordinates p in M is constant, so its derivative is zero. Body rotation around fixed axis Main article: Circular Motion Figure 1: Angular Vector of Speed Ω indicates a counterclockwise rotation and down clockwise as stated in the right rule. The angular position of the θ (t) changes over time with the rate of th (t) and dθ/dt. Rotational or angular kinematics is the description of the rotation of the object. The rotation description requires a specific method of orientation description. Common descriptions include Euler angles and kinematic turns caused by algebraic products. In the next, attention is limited to a simple rotation around the fixed orientation axis. a z-axis was chosen for convenience. Position This allows the description of rotation as the angular position of the M-standard reference frame in relation to the fixed F of this common z-axis. The coordinates of p--h, d) in M are associated with coordinates P q (X, Y) in F by matrix equation: P (t) - a (t) , displaystyle (t θ θ θ θ) (t) - display style A't) begins bmatrixcos (t)-sin (t)sin (t)'sin (t) sin (t) cos theta (t)end'bmatrix Determining the angular position of M relative to F as function F. Speed If the p point does not move in M, its speed in F is given V P and P ¨ Display-style (B) P point (P) Conveniently eliminate the p coordinates and write it as an operation on the trajectory of P (t), V P - A ˙(t) - A (t Ω) Omemaff (P) where the matrix Ω (0) displaystyle Omega beginning bmatrix 0. omega omega omega 0endbmatrix , known as the angular speed matrix M relative to F. The setting is a derivative of time from the angle of the θ, that is: d θ d t. Display style omega frak d'ata dt. Acceleration The acceleration of P(t) in F is obtained as the time derivative of the velocity, A P = P¨(t) = [Ω ˙] P + [Ω] P ˙, {\displaystyle \mathbf {A} _{P}={\ddot {P}}(t)=[{\dot {\Omega }}]\mathbf {P} +[\Omega]{\dot {\mathbf {P} }},} which becomes A P = [Ω ˙] P + [Ω] [Ω] P , {\displaystyle \mathbf {A} _{P}=[{\dot {\Omega }}]\mathbf {P} +[\Omega][\Omega]\mathbf {P} ,} where [Ω ˙] = [0 − α α 0] , {\displaystyle [{\dot {\Omega }}]={\begin{bmatrix}0&-\alpha \\\alpha &0\end{bmatrix}},} is the angular acceleration matrix of M on F, and α = d 2 θ d t 2 . Displaystyle Alpha {2} ({2}). The rotation description then includes these three quantities: Corner position: the oriented distance from the chosen origin on the rotation axis to the point of the object vector r (t) the location of the point. Vector r(t) has some projection (or, accordingly, some component) r⊥(t) on the plane perpendicular to the axis Then the angular position of this point is the angle of the θ from the reference axis (usually a positive x axis) to the r⊥ (t) vector in a certain sense of rotation (usually taking into account the right rule). Corner speed: Angular speed is the speed at which the angular position of the θ changes in relation to the time t: d θ d t Corner speed is represented in figure 1 by a vector Ω indicating along the axis of rotation with the size and meaning determined by the direction of rotation, as given by the right rule. Corner acceleration: The magnitude of the angular acceleration of the α is the speed at which angular speed changes in relation to the time t: α y d displaystyle alpha frak d'omega dt Equation of translation kinematics can be easily extended to plan kinatic rotation for constant angular acceleration with simple variable exchanges: f - I - α t displaystyle θ (omega) matemarma θ (f) 2 α t 2 display (themes) (matemarma) (matemarma) I (omega) matemarma ya (t'tfrac {1}{2})t'alpha t'{2} θ f θ. display style (taka) (matemarma) --matemarma (matemarma) {1}{2} (omega-matrmema θ θ α (omega-matmehehememia) Display style omegaMathar {2}mehmeham (matemarma) {2}2 Alpha (Ata (Matthewrm (f) Here θi and θf, respectively, are the original and final corner positions, qi and zf are, accordingly, the initial and final angular velocity, and α is a constant angular acceleration. Like angular speed, the angle itself is not a true vector. Point trajectories of the body in three dimensions Important formulas in kinematics determine the speed and acceleration of points in the moving body as they track trajectories in three-dimensional space. This is especially important for the center of body mass, which is used to produce motion equations using either Newton's second law or the Lagrange equation. Position To determine these formulas, the movement of component B of the mechanical system is determined by a set of rotations (A(t)) and translations d(t) collected in a homogeneous transformation (T/t) . If p is the coordinates of point P in B, measured in a moving reference frame M, the trajectory of this point, traced in F, is given: P (t) - T (t) Display-style textbft/t)t)textbf (p'start) Bmatrix (textbf) trix (beginning) bmatrix (a(t) textbf (d't)0'1'end'btrix This notation does not distinguish between P (X, Y, q, 1) and P (X, Y, q), which is hopefully clear in context. This equation for trajectory P can be inverted to calculate the vector of the coordinates p in M as: p - t (t) - 1 P (t) . Displaystyle textbfnt)-1textbf (PL(tBeginning of BmatrixTextbf (p'1'endBmatrix's start'bmatrix)A ((t) TK--A(t) T't's (d't)0'1'endbmatrixbeginning Bmatrixtextbf (P) (t) This expression uses the fact that transposing the rotation matrix is also its reverse, i.e.: Displaystyle (A(t) (TSA(t)I.A.! , V P - T - T ˙(t˙˙˙) . Display-style textbf weP Point (TK (t)Textbf (p'start)Bmatrix'textbf (WP) Point 0endBmatrix (beginning) Bmatrix (t)Textbf (d'(t)01'end Bmatrixtextbf (p'1'endBmatrix'startbmatrix'dot (t) BFBF (t)0'0'end'bmatrix'beginning BmatrixTextbf (p'1'end)Bmatrix. because p is permanent, Its derivative is zero. Working on its trajectory P (t), measured in a fixed frame F. Replacing the reverse conversion for p in the speed equation gives: V P - T ˙(t ˙) 0 x 0 x 0 x 1 x 1 x 1 q 1 (t . . . . . ¨. . . . . 1 - ˙AA 1 - And ¨And 1 x x 1 x x 0 0 ˙˙˙ 0 x

(t.. Displaystyle (beginning) aligned textbf (VEP) dot T (t)t)-1textbf (PL (t) begins Bmatrix textbf (W.P.) 0'end'Bmatrix's begin'bmatrix'dot (point A'bmatrix) (point A'bmatrix) (point A'bmatrix) (dot A'bmatrix) (point A'bmatrix) (dot A'bmatrix) (dot A'bmatrix) (dot A'bmatrix) (dot A'bmatrix) (dot A'bmatrix) (dot A'bmatrix) (point A'bmatrix) (dot A'bmatrix) (dot A'bmatrix) (dot A'bmatrix) (dot A'bmatrix) (dot A'bmatrix) (dot) textbf)d'end'bmatrix'start'bmatrix, A'textbf 1'end'bmatrix'-1'start'Bmatrix'textbf (P)(t) 0'0'end'bmatrix-A'-1'bmatrix-1'-text (d'0'A'end'bmatrix'begin'Bmatrix'textbf (P'(t) the end of Bmatrix begins bmatrix point (ASA-1)-dot Azaz-1 textbf (d) (0'end'bmatrix) start Bmatrixtextbfbf (P) (t) ''1'end'Bmatrix's begin'bmatrix'dot 'AST-dot 'Azat'Textbf (de-dot)textbf (d'textbf)0'0'endbmatrix'start Bmatrix Textbf (PL(t)1'end ,Bmatrix'textbf (P) : S - Ω - Ω d d 0 0 0 - display style. where Ω is ˙A T, the Omega display is an angular speed matrix. Multiplying by the S operator, the FORMULA for VP speed takes the form: V P and Ω × (P ˙q d) textbff d) the point textbf domega time textbf RP/Otextbf VO), where the vector is the angular vector of velocity derived from the components of the matrix (Ω); R P/O q P q d, displaystyle textbf RPP/O'textbf (P-Textbf (d) is the P position in relation to the origin of the O moving frame M; and V O q d ˙, displaystyle textbf V (Point) is the speed of origin of O. Acceleration Acceleration Point P in moving corps B is obtained as a derivative of the time of its vector of speed: A q P q d d t p d d d ˙˙˙ (Displaystyle textbf AP-frak (de-dt) textbf (VEP) Frak (de-dt) large (Se text)) PAM (P) dot (SE TEXTBF) This equation can be expanded, first, by computation (S ˙- Ω - Ω d Ω d d Ω Ω 0 0 Display Style (dot) Se-textbf (SOUTH) start bmatrix dot (Omega) --textbf (Om) 0'endbmatrix'start'bmatrix'dot (Omega) - omega dot Omega textbf (de Omega) z.z.0'end'bmatrix and S No 2 - Ω th Ω d - V O 0 0 - 2 - Ω 2 - Ω 2 d - Ω V O 0 0 . Displaystyle (SH{2} begins Bmatrix Omega,-Omega (textbf) (de textbf) (WSO) 0'0'endbmatrix ({2} Start bmatrix Omega (Omega {2})-Omega {2}textbf deOmega textbf (W.O.) Formula for acceleration AP can now be obtained as: P and Ω ˙(P q d) - A O y Ω 2 (P q d) , (Textbff (Lp-Textbf (de-de))-textbf (A)O'Omega No {2} (Textbf (P-Textbf) or P α × R P / O - × - × R P/O - A O , Omega time textbf (R'P/O'textbf) where α is an angular acceleration vector derived from the angular speed matrix; R P/O - P - d , displaystyle textbf RP/O'textbf (P-Textbf (d) is a vector of relative position (P position in relation to the origin of O moving frame M); and A O d q displaystyle textbf AO'ddot (textbf)d'dbf (d'd'd) is the acceleration of moving frames M. Kinematic limitations Kinematic limitations are limitations on the movement of components of the mechanical system. Kinematic it can be considered that they have two main shapes, (i) limitations arising from loops, sliders and fist joints that determine the design of a system called holomic restraints, and (ii) restrictions imposed on the speed of the system, such as limiting knife-edge skates on a flat plane, or skating without a slip disc or sphere in contact with a plane called non-holomic restrictions. Here are some general examples: The cinematic connection of kinematic communication accurately limits all 6 degrees of freedom. Riding without sliding Object, which rolls on the surface without sliding, obeys the condition that the speed of its center of mass is equal to the cross product of its angular velocity with the vector from the point of contact to the center of mass: v G (t) - Ω × r G/O . Display style boldsymbol vG(t) boldsimbol Omega time boldsymbol rG/O. In the case of an object that does not tip or does not rotate, it boils down to v q r 'displaystyle v'r'omega . An inexhaustible cord is a case where the bodies are connected by an idealized cord that remains in suspense and cannot change the length. The limitation is that the length of all cord segments is the total length, and therefore the time derived from this amount is zero. The dynamic problem of this type is the pendulum. Another example is a drum turned by gravity when a weight falls attached to the rim by an inexhaustible cord. The equilibrium problem (i.e. not cinematic) of this type is the caenary. Cinematic pairs Main article: Reuleaux's kinematic pair named the ideal connections between the components that form machine kinematic pairs. It differed between the higher pairs, which are said to have linear contact between the two links, and the lower pairs that have contact between the links. J. Phillips shows that there are many ways to build pairs that don't fit this simple classification. The lower pair lower vapor lower vapor is an ideal joint, or holonomic restriction that maintains contact between a point, line or plane in a moving solid (three-dimensional) body corresponding to a point line or plane in a fixed solid body. There are the following cases: a revolute vapor, or hinged joint, requires a line, or axis, in a moving organ to remain solid with a line in a fixed body, and the plane perpendicular to this line in a moving body maintain contact with a similar perpendicular plane in a fixed body. This imposes five restrictions on the relative movement of the links, which therefore has one degree of freedom, which is the pure rotation around the hinge axis. A prismatic joint, or slider, requires that the line, or axis, in the moving enclosure remain colina with a line in a fixed and the plane parallel to this line in the moving body maintain contact with a similar parallel plane in the fixed body. This imposes five restrictions on the relative movement of links, which therefore has one degree of freedom. This degree of freedom is the distance from the slide along the line. The cylindrical joint requires that the line, or axis, in the movement of the body remains solid with the line in the fixed body. It is a combination of a revolutive joint and a sliding joint. This joint has two degrees of freedom. The position of the moving body is determined by both rotation and sliding on the axis. A spherical joint, or joint ball, requires that the point in the moving body maintain contact with a point in the fixed body. This joint has three degrees of freedom. The planar joint requires that the aircraft in the moving hull maintain contact with the plane in a fixed body. This joint has three degrees of freedom. Higher pairs Generally speaking, higher vapor is a limitation that requires a curve or surface in the movement of the body to maintain contact with a curve or surface in a fixed body. For example, contact between the camera and its follower is a higher pair called a fist joint. Similarly, the contact between the curved curves that form the mesh teeth of the two gears are fist joints. Kinematic Circuit Illustration of communication from four bars from Kinematics of Machinery, 1876 Rigid bodies (links) connected by cinematic pairs (connections), known as kinematic chains. Mechanisms and robots are examples of kinematic circuits. The degree of freedom of the kinematic chain is calculated from the number of links and the number and type of joints using the mobility formula. This formula can also be used to list the topologies of kinematic circuits that have a certain degree of freedom, which is known as type synthesis in machine design. Examples of Planar one degree of freedom ties collected from N links and J hinged or sliding joints are: N-2, j'1 : a two-bar bond that is a lever; N-4, j-4 : the connection between the four bars; No 6, j'7: six bar links. This should have two links (ternary links) that support three joints. There are two different topologies that depend on how these two first-place connections are related. In Watt's topology, two ternary compounds have a common joint; In Stevenson's topology, the two-thorn links have no common joint and are linked by binary references. N-8, j-10 : eight-bar connection with 16 different topology; N-10, j-13 : ten bar connection with 230 different topologies; N-12, j'16 : twelve bar links with 6856 topologies. For larger chains and their linkages, see R. P. Sunkari and L. C. Schmidt, Structural Synthesis of Planar Kinematic Circuits by adapting the Mackay-type algorithm, mechanism and machine theory #41, p. 1021-1030 (2006). See Absement Acceleration Analytical Mechanics Applied Mechanics Celestial Mechanics Centration Force Classical Mechanics Mechanics Dynamics (Physics) The Fictitious Power Forward Kinematics Four-Bar Communication Reverse Cinematic Jerk (Physics) Laws Kepler Kinematic Communication Kinematic Diagram Kinematic Synthesis Kinetic (Physics) Movement (Physics) Orbital Mechanics Static Speed Integrated Cinematics Chebychev-Grubler-Kutler-Kutz Chapter 1. ISBN 0-521-35883-3. Joseph Stiles Beggs (1983). Kinematics. Taylor and Frances. page 1. ISBN 0-89116-355-7. Thomas Wallace Wright (1896). Elements of mechanics, including kinematics, kinetics and statics. E and FN Spohn. Chapter 1. Russell K. Hebbeler (2009). Kinematics and kinetics of the particle. Engineering Mechanics: Dynamics (12th place). Prentice Hall. page 298. ISBN 0-13-607791-9. Ahmed A. Shabana (2003). Reference cinematographics. Dynamics of multi-body systems (2nd place). Cambridge University Press. ISBN 978-0-521-54411-5. .. 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