ANALYSIS OF 2- OR 3-DIMENSIONAL MOTION v1.1

The program analyzes the 2- or 3-dimensional motion of a body or projectile. It handles the following quantities:

Accelerations: *ax,ay,az*, which may be constant or time dependent,

motion quantities and initial conditions for *t*=0: *vx,vy,vz,x,y,z*,*vx0,vy0,vz0,x0,y0,z0,* and time *t*

For a 2-dimensional calculation all *z*-values are omitted.

For an analysis in 3 dimensions the y-axis is assumed to point upwards, while the x- and z-axis form the ground plane (right-handed screw).

In the following section numbers in brackets refer to a 2 dimensional analysis.

Besides the accelerations, 7 (5) variables has to be input out of the 12 (8) unknown motion quantities as numerical value and the program solves for time variable *t* and the remaining 5 (3) quantities, which have to be entered by their names as listed above, otherwise, if only 6 (4) numerical inputs out of the motion- and initial quantities list are done, the program prompts to enter a value for *t*

(cf. example 2).

Any angles entered are assumed to be in radians, so if one in degrees is entered, a degree symbol (°) must be used (cf. example 1).

To start the program, select motion3d() from the var-menu and fill out the brackets by the input of ***3***

to motion3d(3) for a 3- dimensional calculation, otherwise enter motion3d(2). Now key in on the following prompts *{ax,ay,az},{vx,vy,vz},{vx0,vy0,vz0},{x,y,z}, {x0,y0,z0}* the appropriate values. After the output of the result the program prompts for a new calculation with any quantity changed (**1**) or to quit the program (**0**).

***EXAMPLE 1:***

A projectile is launched from (0,0,0) with initial velocity [*v0*] = [40\*cos(32°) , 40\*sin(32°) , 11] m/s.

It lands at (*x,18,z* ) m. The gravitation is assumed to be 9.81 m/s**2**

1. Find the coordinates of the landing point and the time of flight.
2. Find the maximum altitude reached. ( *vy=0* )

Select motion3d(3) and enter:

*{ax,ay(,az)} :* {0,-9.81,0}

*{vx,vy(,vz)} :* {*vx,vy,vz*}

*{vx0,vy0(,vz0)} :* {40\*cos(32°),40\*sin(32°),11}

*{x,y(,z)}:* { *x,18,z}*

*{x0,y0(,z0)}:{0,0,0}*

1. The result is:

[*t x z vx vy vz*] =

3.16 107.2 34.76 33.92 -9.805 11

1.161 39.39 12.77 33.92 9.805 11

1. Now key in ***1*** to run the program again and change only the following inputs:

*{vx,vy(,vz)} :* {*vx,0,vz*}

*{x,y(,z)}:* { *x,y,z}*

Solution:

[*t x y z vx vz*] =

[2.161 73.3 22.9 23.77 33.92 11]

***EXAMPLE 2:***

A particle at [*x0*]=[*0.5,0.3*] m is submitted to an acceleration [*a*]*=* [-*1.6\*cos(2\*t),*

*-9.81\*exp(-t)*] m/s**2** with initial velocity [*v0*] *=* [*-2,8*] m/s.

1. Find its position and velocity at *t=2* s
2. What is the maximum altitude and when will it be reached?

Select motion3d(2) and enter:

*{ax,ay(,az)} :* {-*1.6\*cos(2\*t),-9.81\*exp(-t)*}

*{vx,vy(,vz} :* {*vx,vy*}

*{vx0,vy0(,vz0)} :* {*-2,8*}

*{x,y(,z)}:* { *x,y}*

*{x0,y0(,z0)}:{0.5,0.3}*

*t = 2*

Solution a):

*t=2* [*x y vx,vy*] =

[*-4.1615 5.1624 -1.3946 -048236*]

Now key in ***1*** to run the program again and change only the following inputs:

*{vx,vy(,vz)} :* {*vx,0*}

*{x,y(,z)}:* { *x,y}*

Solution b):

[*t x y vx*] =

[*1.6901 -3.6688 5.241 -1.811*] . At t=1.69 s the maximum altitude is y=5.24 m

***EXAMPLE 3:***

A particle at [*x0*]=[*0,0* ] being subject to an acceleration [*a*]*=* [-*2/(t+1),-9.81*] has at time *t* the velocity [*v*] = [*3,2*] and the position [*x*] = [*8,y*]. Find the appropriate time *t* and the initial velocity [*v0*] at *t*=0.

Select motion3d(2) and enter:

*{ax,ay(,az)} :* {-*2/(t+1),-9.81*}

*{vx,vy(,vz} :* {*3,2*}

*{vx0,vy0(,vz0)} :* {*vx0,vy0*}

*{x,y(,z)}:* { *8,y}*

*{x0,y0(,z0)}:{0,0}*

Solution:

[*t y vx0 vy0*] =

[*2.0455 24.613 5.2273 22.066*]

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