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APPLICATION OF KINEMATICS SIMULATION SYSTEMS USING SHARK MODELS

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***Abstract*—**The objective of this paper is to present the methodology to be followed for more accurate simulation of a kinematics system using Shark program. By introducing kinematics parameters we can improve the comportment of the vehicle and the way he respond to the combined stress taken from the road. In the second part, these kinematics conditions will be combined to generate a complex kinematics system. In our case we use kinematics conditions to simulate complex systems of vehicle chassis assemblies.

***Keywords*—**Kinematics, front axle, results, loadings, chassis

I. Introduction

KINEMATICS – wheel travel, according to DIN (Deutsches Institut für Normung) often also called wheel (or steering/suspension) geometry – describes the movement caused in the wheels during vertical suspension travel and steering, whereas 'elastokinematics' defines the alterations in the position of the wheels caused by forces and moments between the tires and the road [1].
If we take an older definition of the kinematics defined by T.W. Wright it would be: "one body is said to be in motion relative to another body when it changes its position with respect to that other" [2].
Dynamics simulation events (Mechanical Event Simulation - MES) are a class of specialized simulation programs for more realistic analysis of the functioning assemblies to reduce the number of experiments on physical models and laboratory tests.
In spite of numerous past investigation and vast investments of research time and money, vehicle motion stability remains one of the most important unresolved problems of road vehicle transportation. In other words, vehicle stability is the ultimate goal of the study of vehicle resistance to various motion perturbations [3].
Sufficient vertical spring travel, possibly combined with the horizontal movement of the wheel away from an uneven area of the road (kinematic wheel) is required for reasons of ride comfort [1].
The so-called effective axle characteristics are derived from the individual tyre characteristics and the relevant properties of the suspension and steering system [4].
The mechanism is a closed kinematics chain; the kinematic chain is compound or simple and consist of kinematic pairs of elements; these carry the envelopes required for the motion witch the bodies in contact must have, and by these all motions other than those desired in the mechanism are prevented [5].
On many production cars one of the only ways of improving roadholding is the fitting of stiffer springs or anti-roll bars-both of wich have much the same effect. This applies particulary at the front, where the types of independent suspension most commonly used are subject to considerable camber change on roll [6].
The torque steer effects depend on the size of the change in the longitudinal force, the adherence potential between the tyres and the road, the tyres and the kinematic and elastokinematic chassis design [1].
Our interest was to generate a complex cinematic model, which can be used to simulate various types of front axle and can be easily adapted to the front axle requirements modifications.
In order to generate complex kinematics using Shark software we first need to generate linear front axle.
The viewing angles in the GUI are enabled using the function: Graphics / View Definition Values provided to be placed in one of three orthogonal views.

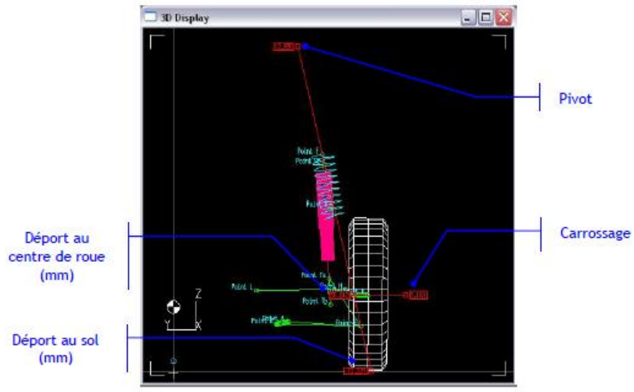
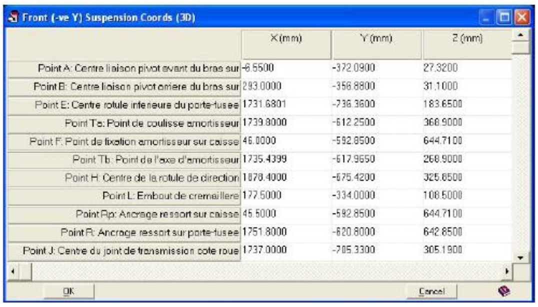


Fig. 1. McPherson front axle kinematics model

II. METHODS AND MATERIALS

In order to generate the complex kinematics model we need to introduce the data entry first, that take in to the accounts the coordinates of the characteristic coordinates.



Front (-ve Y) Suspension Coords (3D)	X (mm)	Y (mm)	Z (mm)
Point A: Centre liaison pivot avant du bras sur	-6.5500	-372.0900	27.3200
Point B: Centre liaison pivot arriere du bras sur	293.0000	-356.8800	31.1000
Point E: Centre rotule inferieure du porte-fusee	1731.6801	-736.3600	183.6500
Point Ta: Point de coulisse amortisseur	1739.8000	-612.2500	368.9000
Point F: Point de fixation amortisseur sur caisse	46.0000	-592.8500	644.7100
Point Tb: Point de l'axe d'amortisseur	1735.4399	-617.9650	268.9000
Point H: Centre de la rotule de direction	1878.4000	-675.4200	325.8500
Point L: Embout de cremaillere	177.5000	-334.0000	108.5000
Point Rp: Ancrage ressort sur caisse	45.5000	-592.8500	644.7100
Point R: Ancrage ressort sur porte-fusee	1751.8000	-620.8000	642.8500
Point J: Centre du joint de transmission cote roue	1737.0000	-705.3300	305.1900

Fig. 2. Coordinates of the model

After introducing the coordinate's points we make the kinematics connection between the points of the front axle.

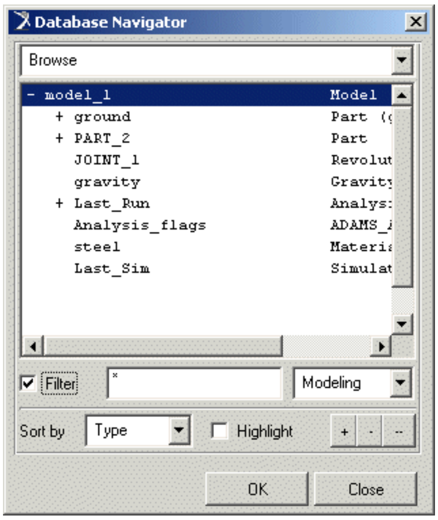


Fig. 3. Construction and modifications of the SHARK model

After the coordinates introduced and the construction of the front axle is ready, we can insert the files obtained after the computing of the weight and the force and moments which has been computed with ADAMS car program.

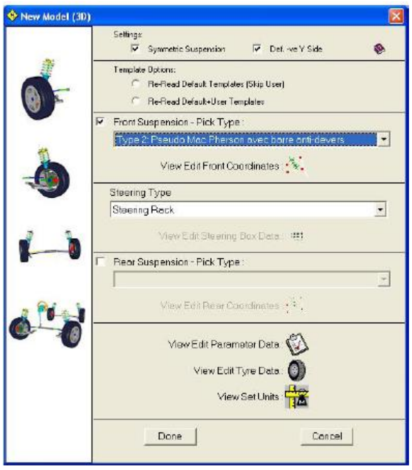


Fig. 4. Charging the Pseudo-Mac Pherson template

The first step is to charge the template of « Pseudo-Mac Pherson avec barre anti-devers » type.

For this we need to File/ New then activate the case Front Suspension and select Type 2.

It is necessary to calculate the outputs using the transmission, by integrating it using:

- Enter in the menu: Edit / Add to Model / Drive Shaft (s)
- Select the type " length IJ fixed" en click on Fixed Length Drive Shaft

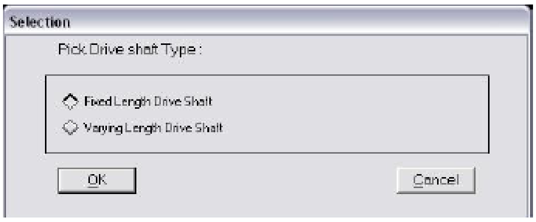


Fig. 5. Charging the transmission type

A window will appear to notify that the template is going to be modified and that's why we need to save the model: validate with one click on OK button

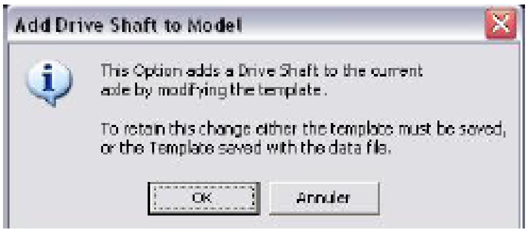


Fig. 6. Validate the accepted model and save menu

Two new points are then created:

- Inboard CV Center : Center of transmission gear box (point I)
- Inner CV Axis point : Orientation point for the axis (point Ip)

Return on Edit mode by clicking on the icon: 

On the graphic interface, click on the two newly created points and update their nomination and coordinates.

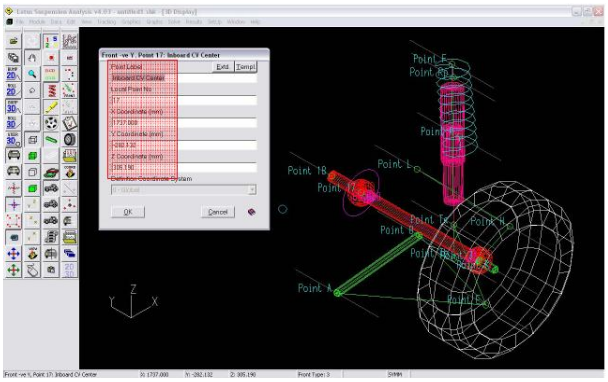


Fig. 7. Computing calculation and coordinates

The definitions of the values are introduced in the SYSART file [7].

```
!===== CALCUL DU YINT,YI,YEXT =====!
  !COS. DIR. DES 2 ARBRES! CD I1I  = U(1) , CD I J = U(2) ,
  !SIN ET COS DE L'ANGLE DES 2 ARBRES!
   !SIN I! PV U(1) U(2) = U(3) , OS U(3)V(4) = T(1) ,
   !COS I! PS U(1) U(2) = T(2) ,
  !YI!  PS I  V(2) = T(3) ,
 !CALCUL DU DEPORT et de sa VALEUR ABSOLUE!
 OS 24.5*T(1)/T(2) = T(4) , VA T(4) = T(4) ,
  !YINT! OS T(3)-T(4) = T(6) , !YEXT! OS T(3)+T(4) = T(5) ,
  PR (T7,'YINT=',F8.2,'  YI=',F8.2,'  YEXT=',F8.2)  T(6)-T(3)-T(5) ,
```

Fig. 8. SYSART file values defined

The information regarding the joint of transmission with gear box is accessible using:

Data->Compliance Data->Drive Shaft Properties.

Transverse arms and trailing arms ensure the desired kinematic behaviour of the rebounding and jouncing wheels and also transfer the wheel loadings to the body [1].

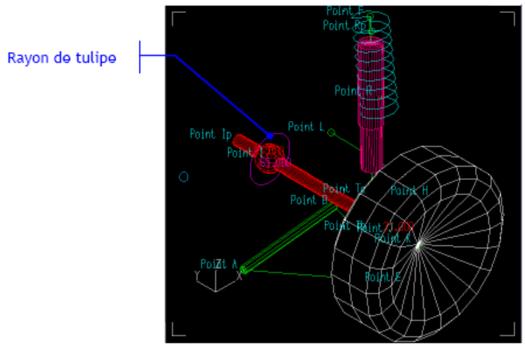


Fig. 9. Joint of transmission with gear box information

The information's about wheels are displayed as follows:

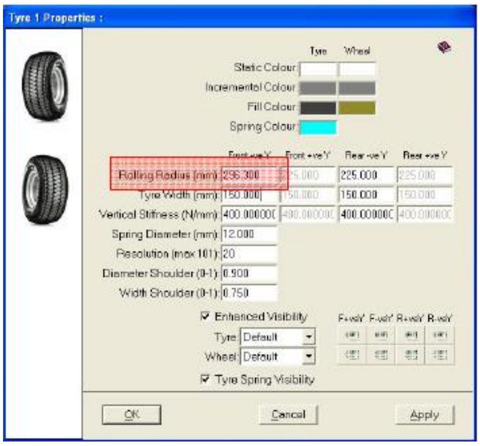
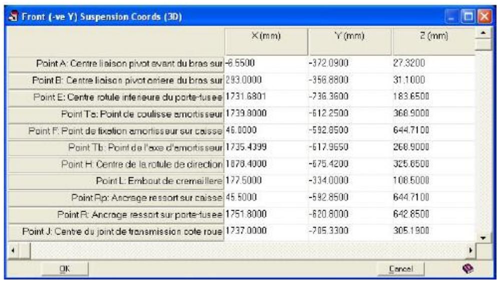


Fig. 10. Wheel menu information

The point's coordinates, on the vehicle system axis, are readable on the POINTS paragraph in the SYSART file. These points have the same name as the ones used on the SHARK.

In order to make the update of the points click on the icon: 

After clicking the icon a window will appear to fill out the coordinates as follows:



Front (-ve Y) Suspension Coords (3D)

	X (mm)	Y (mm)	Z (mm)
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Point F: Point de fixation amortisseur sur caisse	46.0000	-592.8500	644.7100
Point Tb: Point de l'axe d'amortisseur	1735.4399	-617.9650	268.9000
Point H: Centre de la rotule de direction	1878.4000	-675.4200	325.8500
Point L: Embout de cremaillere	177.5000	-334.0000	108.5000
Point Rp: Ancrage ressort sur caisse	45.5000	-592.8500	644.7100
Point R: Ancrage ressort sur porte-fusee	1751.8000	-620.8000	642.8500
Point J: Centre du joint de transmission cote roue	1737.0000	-705.3300	305.1900

Fig. 11. Window with the coordinates o be introduced

For the movement of the train and moving positions of the wheels we take these further steps:

Define the Z pilot move:

Solve-> Motion-> Ground Plane Options-> Move TCP Z (point Q)

Move Wheel Centre Z (point K)

Move Lower Ball Joint Z (point E)

Move Upper Ball Joint Z (point F of double triangle)

For specifications on absolute Z position make the selection:

Solve-> Motion-> Ground Plane Options-> Z displacement as position (if not the values entered correspond on the models motion).

For specifications on absolute Y position make the selection:

Solve-> Motion-> Ground Plane Options-> Y displacement as position.

Select the displacements combined mode on turnings:

Module / SHARK / 3D Bump (only movement):

3D Roll (rolling only)

3D Steer (Steering only)

3D Combined Motion (movement and steering)

The SYSART document is generated by using the solver ADAMS by computing the loads and displacements of the coordinates of the kinematics points. [8].

The first part of the SYSART generated file takes in to account all the constrains imposed to the virtual model and the definitions of the coordinates and specific axle points.

```
SYSART
PARAMETRES:
!Rayon du Pneumatique pour Calculs!          /&QK0/296.300/
!Rayon du Pneu pour Calculs-Rayon de Jante!  /&QQ1/51.290/
!Longueur du Corps d'Amortisseur(T-T3)!      /&CORPS/450.000/
!Longueur de la Tige d'Amortisseur(F-T5)!    /&TIGE/0.000/ ;
150 0 1 0 0.001      PM00
Train avant X74 avec BAD sur element porteur - pmv74bad.dat
$ points du porte-fusee mis a jour par rapport au plan de piece !
$ origine en Y du repere porte-fusee = face d'appui roue sur disque !
 /CAISSE/
 A  ZP=B  B  !Ancrages du bras/caisse (avant-arriere)!
 F  ZP=OF OF !Ancrage de l'amortisseur/caisse!
 R1 R3       !Ancrage et debut du ressort/caisse!
 M1 ZP=M2 M2 !Ancrages de la barre anti-roulis!
 I1 ZP=I2 I2 !Sortie de la transmission cote pont!
 OI OJ       !Pour les joints CONV de la transmission (pour Adams)!
 L1 ZP=L2 L2 !Boitier de cremaillere!                          TYPE=8 ,
 /BRAS/          A  ZP=B  XP=E  B  E          BASE: A  B  E  TYPE=3 ,
 /PORTE-FUSEE/   E  T  T3 ZP=F  R  H  G  K  ZP=G  P1 OE OH P
                                              BASE: E  K  G  TYPE=6 ,
 /ROUE/   (R)    G  K  ZP=G  Q  J  ZP=K  XP=OJ               TYPE=4 ,
 /SORTIE CREMAILLERE/      L  L1 ZP=L2 CC Oc    BASE: L  OC Oc TYPE=(L1-L) ,
 /BIELLETTE DE DIRECTION/  L  H  OL Oh          BASE: H  Oh L  TYPE=(L-H) ,
 /BARRE ANTI-ROULIS/       M2 M1 ZP=M2 P1 ZP=OP OP BASE: M2 M1 P1 TYPE=5 ,
 /BIELLETTE DE BARRE ANTI-ROULIS/ P  P1 ZP=Op Op               TYPE=2 ,
 /TIGE AMORTISSEUR/   F  ZP=Of T3 ZP=F  Of                     TYPE=(F-T3) ,
 /TRANSMISSION/ I  ZP=J  XP=OI J  ZP=I  XP=OJ                  TYPE=2 ,
 /SORTIE GI/    I1 ZP=I2 I  ZP=I1 XP=OI                        TYPE=(I1-I) ,
 /NOIX EN P1/              OP Op                                    ,
 /NOIX EN F/               OF Of                                    ,
 /NOIX EN H/               OH OL                                    ;

NOEUDS: R  , R1 ;

GLISSIERE: L2 L1 L  ;
COULISSES: T  T3 F  , I2 I1 I  ;

CARDAN: OL OH H  L  ;

JOINTS:
 A  REVO , E  SPHE , F  UNIV , H  SPHE ,
 I1 CYLI , I  CONV , J  CONV ,
 L  SPHE , L1 TRAN ,
 M1 REVO , P  SPHE , P1 UNIV ,
 T3 CYLI ,
 K  REVO ;
```

Fig. 12. The first part of the SYSART file

The second part of the SYSART generated file takes in to account the links between the coordinates points defined in to the first part os the SYSART file.

```
POINTS:
 /Ancrage avant du bras sur caisse/
 A      -6.55    -372.09      27.32   ,
 /Ancrage arriere du bras sur caisse/
 B    293        -356.88      31.1    ,
 /Point de fixation de l'amortisseur sur la caisse/
 F      46       -592.6      650.18   ,
 /Ancrage du ressort sur la caisse/
 R1     45.5     -592.85     644.71   ,
 /Debut du ressort sur la caisse/
 R3   145.086    -592.85     635.622 ,
 /Centre gauche de rotation de la barre anti-roulis/
 M1   264        -546.3       91      ,
 /Centre droit de rotation de la barre anti-roulis/
 M2   264         546.3       91      ,
 /Ancrage de la biellette de barre anti-roulis sur le bras/
 P      75.188   -563.812    439.384 ,
 /Embout de la barre anti-roulis/
 P1     61.621   -546.3      161.265 ,
 /Sortie gauche de la transmission cote pont/
 I1    -11.6     -188.464    147      ,
 /Sortie droite de la transmission cote pont/
 I2    -11.6      188.464    147      ,
 /Point de passage gauche de la cremaillere dans le boitier/
 L1   177.5      -234        108.5    ,
 /Point de passage droit de la cremaillere dans le boitier/
 L2   177.5       234        108.5    ,
 /Centre de la rotule inferieure du porte-fusee/
 E    -10.618    -737.466     27.27   ,
 /Point de l'axe d'amortisseur sur le porte-fusee/
 T       1.336   -615.832    160.75   ,
 /Ancrage du ressort sur le porte-fusee/
 R      31.274   -599.46     488.825 ,
 /Centre de la rotule de direction/
 H    139.498    -708.98     115.754 ,
 /Pied de la perpendiculaire abaissee de l'axe d'amortisseur sur l'axe de fusee/
 G       1.336   -615.832    160.75   ,
 /Centre de roue/
 K       1.738   -765.036    161.933 ,
 /Centre du joint de transmission cote roue/
 J       1.563   -700.039    161.418 ,
 /Embout de cremaillere/
 L    177.5      -334        108.5    ,
```

Fig. 13. The second part of the SYSART file

After finishing the steps we will get a full controlled virtual motion kinematics that can be edited and modified for the future models/projects.

III. CONCLUSION

The results, depending on the design of the chassis, in kinematic and elastokinematic toe-in and camber changes which can be used to compensate for unwanted changes in lateral forces, particularly in the case of multi-link suspensions.

The resulted model after the computing steps has the capacity of replicating and checking the kinematics model with the real movement of the assembly/ auto vehicle pieces.

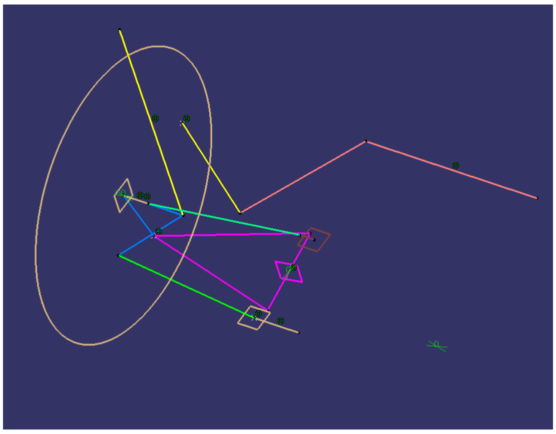

Fig. 14. Kinematics model for the left front axle

This model can also be used to be imported in others CAD or CAE programs who can insert also an accurate 3D model of the assembly or subassembly to be simulated.

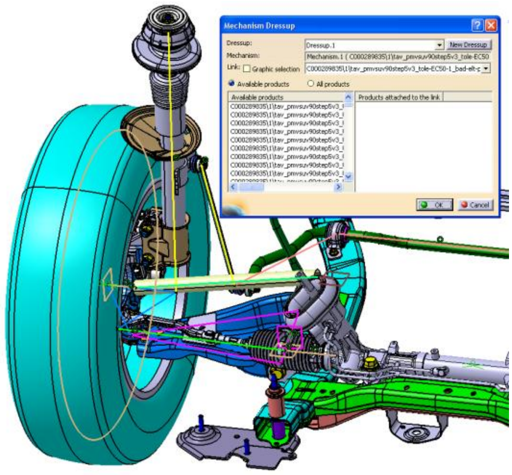

Fig. 15. Kinematics connection usages

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