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Final MN56
Automne 2017

Documents are not allowed
The multiple choice questionnaire lead to 1 point for a correct answer, and -1 for a false answer.

MULTIPLE CHOICE QUESTIONNAIRE

Contact

1. Contact/Friction can be an extremely non-linear event:

   ☐True ☐ False

2. Contact and Friction depend on

   ☐ On the geometry of each deformable body
   ☐ On the material properties of each deformable body
   ☐ None of the above

3. In the common physical sense, surfaces that are in contact have these characteristics:
   a. They can interpenetrate.
   b. They can transmit compressive normal forces and tangential friction forces.
   c. They are free to separate and move away from each other

   ☐True ☐False

4. A contact law is a relationships contact pressure/penetration (Gap).

   ☐True ☐False

5. Frictional force is the force which opposes the relative motion of an object

   ☐True ☐False

6. In the Coulomb Friction law,
    a. Friction force is proportional to normal load.
        ☐True ☐False
    b. That is, the coefficient of friction μ is constant.
        ☐True ☐False

7. In a finite element context, all contact formulations require special algorithms to identify the elements where the contact can occur.

    ☐True ☐False

8. In a finite element context, user must define a master and a slave surface for each contact pair. In general, what differentiates master and slave surface from each other are following:
        a. Nodes on master surface cannot penetrate the slave surface :
            ☐True ☐False
        b. Analytical rigid surfaces and rigid element-based surfaces must always be master surface:
            ☐True ☐False

Penalty Method

9. Contacts using Penalty method always have residual penetration after convergence. This Residual Penetration can be decreased by decreasing the penalty stiffness.

    ☐True ☐False

10. High stiffness leads to reduced penetration and increasing accuracy but higher contact stiffness can also lead to ill-conditioning and divergence.

    ☐True ☐False

11. The contact status is a not very useful sanity check for understanding the global behavior and finding problem areas

    ☐True ☐False

Crash analysis

12. Explicit scheme is unconditionally stable

    ☐True ☐False

13. The Mass scaling method necessarily lead to wrong results because of an increase of the mass of the system

☐True ☐False

14. The time step of a calculation depends only on the material properties of the structure

☐True ☐False

15. Hooke's law can be used to model plastic deformation

☐True ☐False

16. For 3D simulations with solid elements, 4 nodes element are appropriate to simulate a tensile test at high deformation ratio

☐True ☐False

17. The time step is influenced by the mesh size

☐True ☐False

18. The central difference method is expressed as follow: $\Delta t \leq \frac{2}{\omega_{max}}$

Define ω_{max} and the way to calculate it.

19. For structural configuration of of $K = \frac{E.A}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$, and lumped mass matrix $M = \frac{\rho.A.L}{2}\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, calculate det (K-$\omega^2$.M)=0, and show that the time step, for a stable calculation, is linked to material properties.

SPH Methods

20. The SPH method operates integration by a Gaussian quadrature rule instead of the Monte Carlo method

☐True ☐False

21. To obtain an accurate approximation process, the smoothing length has to be taken as big as possible in order to consider an important amount of particles

☐True ☐False

22. The SPH method is formulated with the weighted collocation method

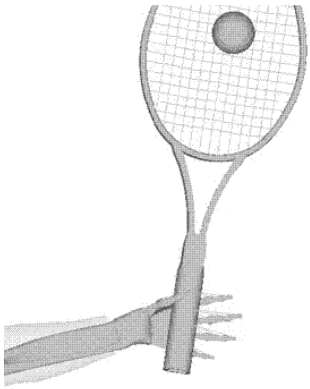
☐True ☐False

23. The SPH method is a Lagrangian method

☐True ☐False

CASE STUDY : FINITE ELEMENT SIMULATION

In this numerical case study, we consider the impact of a ball on a tennis racket, and the influence of the impact on the human arm.
In order to simulate this specific impact case, 3 Finite Element Models are considered and put together into a FE code: racket, the ball and the arm.



24. What kind of mechanical structural has the following governing equation?

$$[K]\{u\} = \{F_{ext}\}$$

25. Could this equation be applied to the case study of arm/racket impacted by the ball? Why?

26. The mesh of the arm consists in 17000 brick elements.
    The mesh of the racket consists in 13000 brick element.
    The mesh of the ball consists in 1200 brick element.
    A lagrangian formulation is used to simulate this impact. Explain why. Name other formulations and explain the context of their use.

27. Concerning the formulations, what kind of formulation can be used for blast simulation? Why?

28. This impact is characterized by a temporal evolution of the mechanical state of the system {arm/racket/tennis ball}. At a numerical level, what are the two kinds of temporal discretization? For one specific discretization and for a lumped mass matrix case, what is the benefit in terms of algorithm resolution?

29. At the opposite of the mesh of the different components, car models in automotive industry are meshed with other kind of elements. Name them and explain why they are used. These kinds of elements are also used with an increase of the number of integration points in the thickness. Explain why.

30. During this simulation, temporal evolution of the system is observed at each time increment. Name this numerical concept, specific to dynamic simulations. What are the factors which influence the time step? You can illustrate your point of view using equations of the Courant's condition.

31. How can you check that a simulation is correct in terms of energy balance?

32. The following graph shows the Energy Balance of the system in the simulation. Comment it.

33. On this graph, several curves are represented. What is the "Hourglass energy"? Explain and describe one of the hourglass mode?

34. It can be observed on this graph that the kinetic energy begins at 28000 mJ. Knowing that the mass of the ball which strikes the racket is 60g, conclude about the impact velocity.

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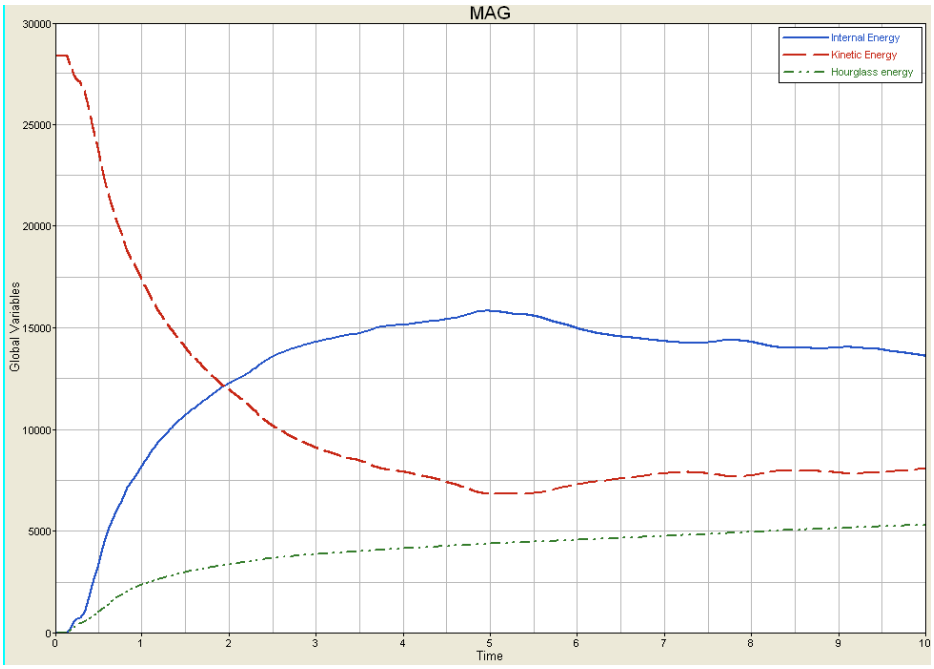


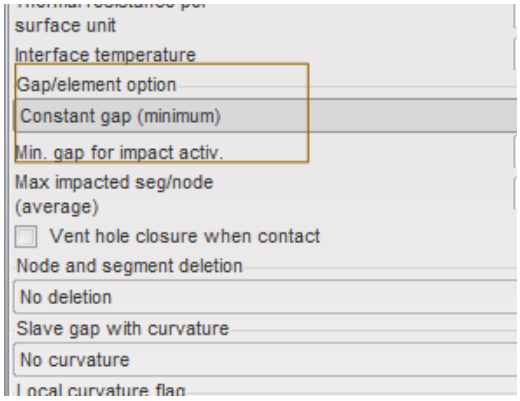
35. Strings of the racket interest us for the simulation. Most of the time, the tennis player strikes the ball without failure of the strings. Sometimes, the strings break. Name a constitutive law you can use to model the mechanical behaviour of the string until failure. What are the main mechanical parameters which are characteristic of this law?

36. If only a typical drive (without string failure) is investigated, how could you simplify the numerical model of the string?

Tennis player use some specific gestures to give both damping effect and aims to the ball. At a numerical level, and in order to reproduce this technical gesture, the definition of specific interfaces is needed in the model:

37. In the problem presented here, where would you define interfaces?

38. In the following figure, the expression gap is used. What is the gap? What is its role in the definition of the interface?



39. How do you define a friction law? Name one.

An objective of this study is also to investigate the mechanical state of the biomechanical model of the arm. For a typical drive, some strains are observed is some soft tissues which may be the cause of the well known “tennis elbow” syndrome.

40. When you have analysed the numerical mechanical state of a specific soft tissue of the arm after the impact, what can you do to ensure that this biological component behave like the reality? Explain the word “biofidelic”.

41. To your opinion, can this specific syndrome occur after one single strike or do these high stress levels in soft tissue have to be repetitive to lead to injuries? Explain this phenomenon at a mechanical point of view. What kind of numerical model could be used to simulate this phenomenon?