UNIVERSITY OF PETROLEUM & ENERGY STUDIES, DEHRADUN
End Semester Examination – December, 2017

Program/course	: B. Tech ADE	Semester	: V
Subject	: Vehicle Dynamics	Max. Marks	: 100
Code	: ADEG 364	Duration	: 3 Hr.
No. of pages	: Ten		

Note:

- **Assume suitable data if missing**
- Draw neat diagrams wherever required
- Give suitable examples in support of your answer
- Be precise in your answer
- **Answer every Question including sub section in a separate new page**

Section A

All Questions Are Compulsory- All Questions Carries Equal Marks – 5 X 4 Marks = 20 Marks

1. For the following Mitsubishi Pajero, moving over a rough road, shown in Figure (1), can be modeled considering

Figure 1 Mitsubishi Pajero

(a) weight of the car body, passengers, seats, front wheels, and rear wheels;
(b) elasticity of tires (suspension), main springs, and seats; and
(c) damping of the seats, shock absorbers, and tires.

Develop three mathematical models of the system using a gradual refinement in the modeling process.

2. From the following, shown in Figure (2), explain effects of Aerodynamic forces and moments acting on a car

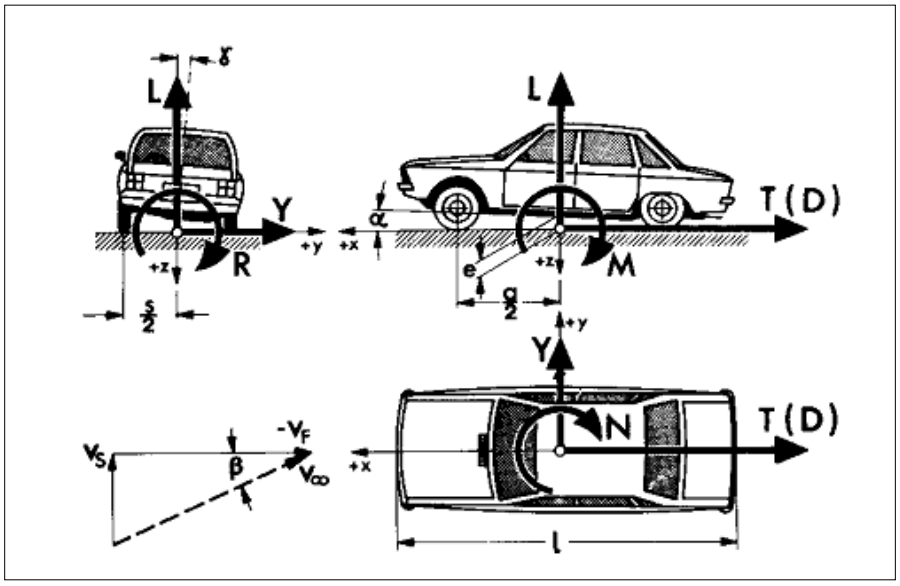

Figure 2 Different Aerodynamic forces acting on the Vehicle

3. The curb weight of a following Continental 4 door sedan, shown in Figure (3), without passengers are 2313 lb on the front axle and 1322 lb on rear axle. The wheel base is 109". Determine the fore and aft position of the center of gravity for the vehicle.

Figure 3 Continental Sedan

4. Explain how actually the change in radius of a tyre at the contact patch has an effect on its velocity. With neat diagram explain the same.

5. Explain the following

a. Who plays the role of spokes in a pneumatic tyre?
b. Air will carry the load in a pneumatic tyre (True/False)
c. Parameters effecting the performance of Visco-elastic material
d. In an assembled tyre assembly, does the wheels pulls its hub towards up or hub pulls the rim towards center? Give the reason in order to support your answer.
e. Explain the essentiality of "WLF" equations for an Visco-elastic tyre.

Section B

Answer All Questions. All Questions carries equal Marks 4 x 10 marks = 40 Marks

6. Derive the Dynamic Axle loads of Ford Mustang 2018 model, shown in Figure (4), considering following assumptions

1. Moving on a gradient
2. Pulling trailer
3. Moving at a speed of 90 kmph
4. Raining also taking place

Figure 4 Ford Mustang 2018 Model

[OR]

7. A Taurus GL Sedan, shown in Figure (5), with its 3.0 L engine accelerates from a standing start up a 6% grade at an acceleration of 6 ft/sec^2. Find the load distribution on their axles at this condition.

Taurus GL Sedan Technical Data:

The curb weight on rear axle is	=	1097 lb
Curb weight on front axle is	=	1949 lb
The wheel base	=	106"

And front passenger's weight is 49% on the front axle and 51% on the rear.

Assuming driver weight is	=	200 lb
Height of C.G.	=	20"

Figure 5 Taurus GL Sedan

8. Determine the front and rear suspension ride rates for a 5.0 L Mustang, shown in Figure (6), given that the tire spring rate is 1198 lb/in. The front suspension rate is 143 lb/in and the rear is 100 lb/in.

Also estimate the natural frequency of the two suspensions when the front tires are loaded to 957 lb and the rear tyres are at 730 lb each.

Figure 6 Mustang 5.Ox

9. You have been given an assignment to select the Steering system for your vehicle, In the market wide variety of steering systems are available like:

a. Recirculating ball type
b. Worm and Sector
c. Worm and Roller
d. Rack and Pinion and
e. Cam and Lever

Choose best steering system and explain the reasons for selecting the same.

10. Determine the equivalent Spring and Damping constants of the following Horizontal Milling Machine, shown in Figure (7), supported on four shock mounts.

(a) Model the elasticity and damping of each shock mount as a spring and a viscous damper,

(b) Find the equivalent spring constant, and the equivalent damping constant, of the machine tool support in terms of the spring constants and damping constants of the mounts.

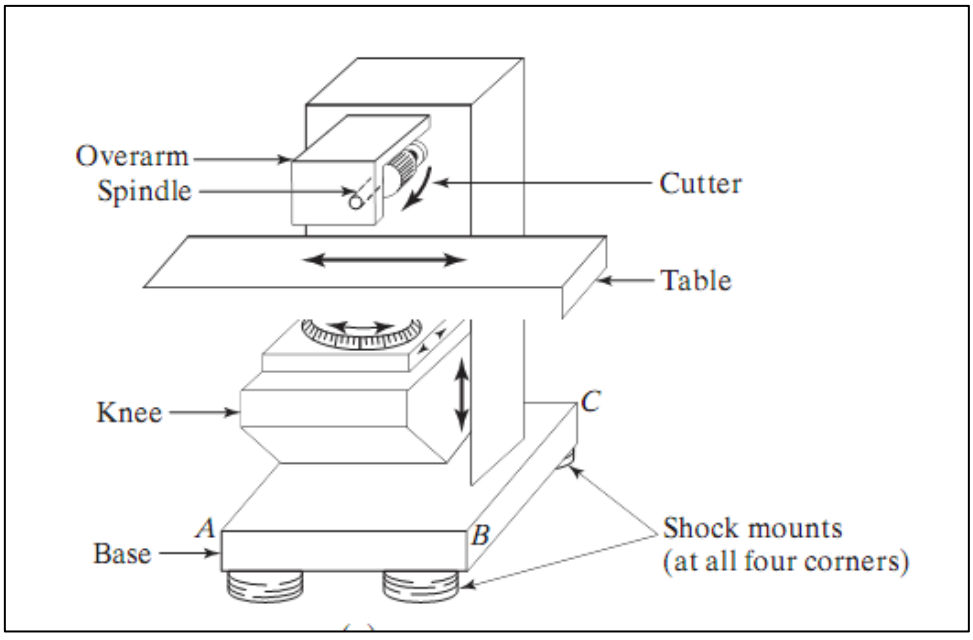

Figure 7 Horizontal Milling Machine

[OR]

11. A cam-follower mechanism, shown in Figure (8), is used to convert the rotary motion of a shaft into the oscillating or reciprocating motion of a valve. The follower system consists of a pushrod of mass a rocker arm of mass and mass moment of inertia about its C.G., a valve of mass and a valve spring of negligible mass. Find the equivalent mass 'm_{eq}' of this cam-follower system by assuming the location of 'm_{eq}' as (i) point A and (ii) point C

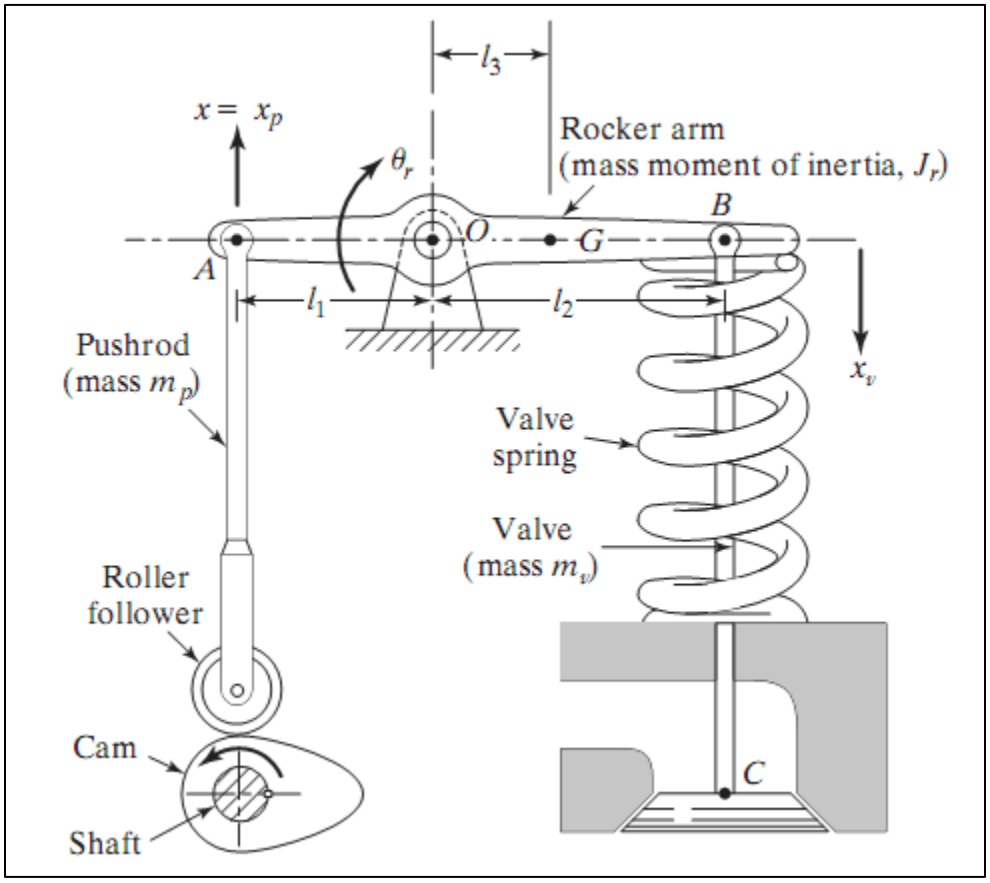

Figure 8 IC Engine Cam-follower Mechanism

Section C

Answer Any Two Questions. All Questions carries equal marks. 2 x 20 marks = 40 marks

12. You are planning to buy a new SUV to pull your boat trailer, shown in Figures (9-11) , out to those long weekends at the lake. Although you like the new front wheel drive (FWD) vans available, You are not sure a FWD will be able to pull the boat up out of the water on some of the steep access ramps you must use.

a) Derive the expressions for the maximum grade it can climb without wheel slippage(traction-limited gradeability) for this combination of Rear wheel drive (RWD) and Four Wheel drive (4WD)

b) Calculate the maximum gradeability for the above two combinations on a ramp with a coefficient of friction 0.3, given the following information on the vehicles.

Van Properties:

Front Axle weight	=	690Kg
Rear Axle weight	=	520Kg
CG Height	=	0.62m
Hitch height	=	350mm
Hitch Rear Overhang	=	58 cm
Wheel Base	=	3050mm

Combined Boat/Trailer Properties:

Axle Weight	=	545Kg
Hitch Load	=	113Kg
Wheel base	=	2800mm
CG Height	=	89cm

In the analysis it is reasonable to assume the longitudinal acceleration is zero, neglect rolling resistance assume the boat is clear of the water so that there are no buoyancy forces on it, ignore any change in hitch height as the forces are applied, and use the small angle approximations.

Figure 9 Pictorial representation of SUV with Boat Trailer

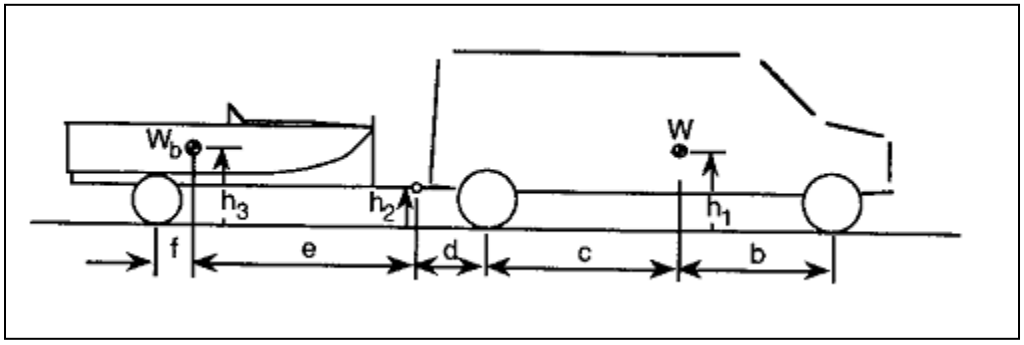

Figure 10 Schematic representation of XUV with Boat Trailer

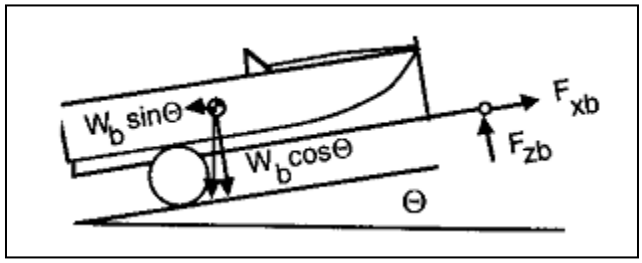

Figure 11 Trailer at gradient

13. Being an Automotive Design Engineer, Design the Rack and Pinion system, shown in Figures (12-13), for the following conditions.

    1. 100% Ackerman
    2. Maximum Displacement of Rack
    3. Calculate the outer wheel drop arm angle
    4. Calculation inner wheel angle

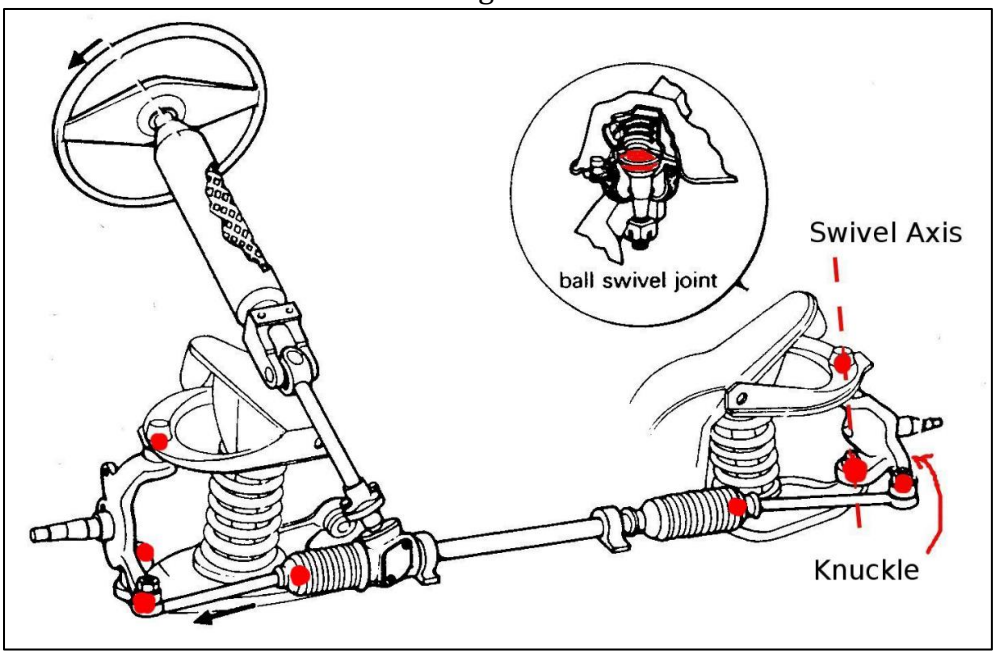

Figure 12 Rack and Pinion steering system

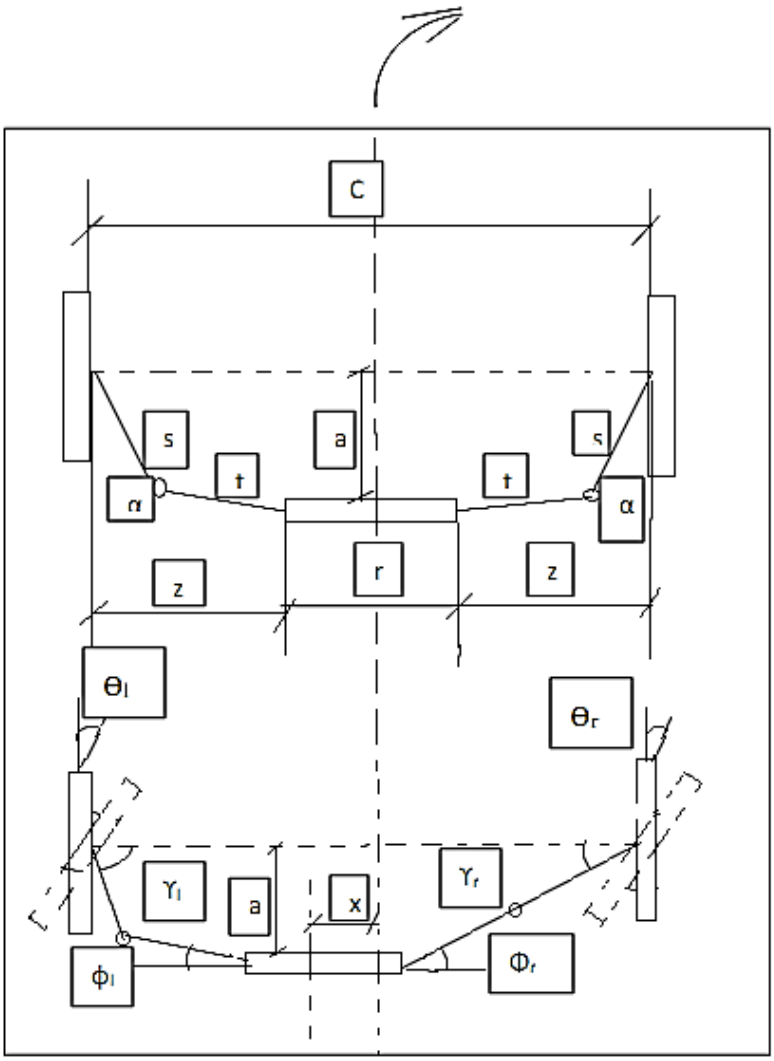

Figure 13 Schematic diagram of Rack and Pinion system

[OR]

14. For the Question 18. Calculate the following

    1. Length of Tie-rod
    2. Calculation of Outer wheel angle
    3. Calculate the inner wheel drop arm angle (by considering Obtuse angle)

15. While designing the any suspension system, shown in Figure (14), choose the favorable conditions for best suspension system. Explain the reasons along with technical discussions for its selection.

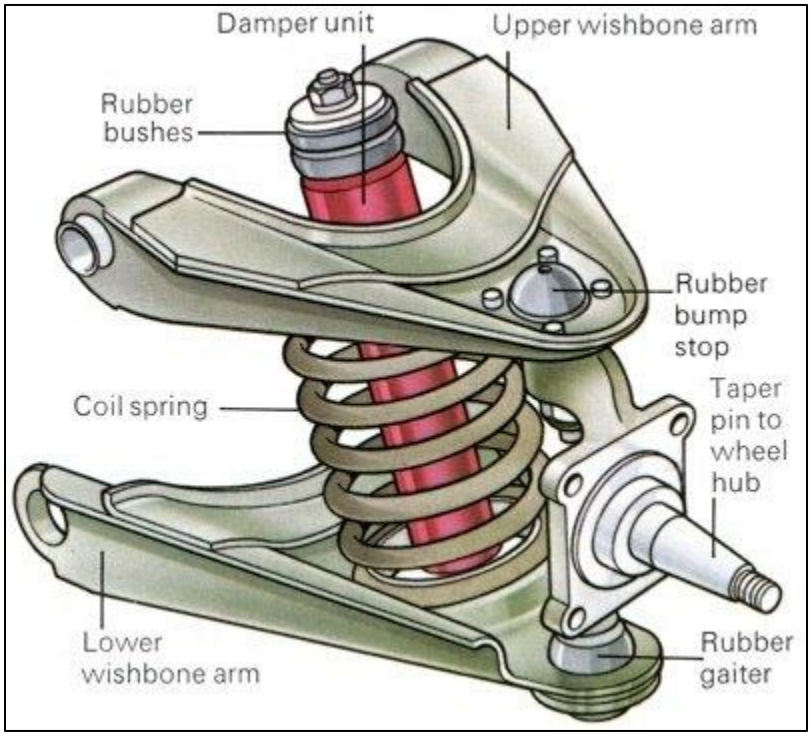

Figure 14 'A' type Wishbone Suspension System