1080/221
AUTOMOBILE AND PRIME MOVERS
ENGINEERING I
(VEHICLE DYNAMICS AND CONTROL)
Oct./Nov. 2010
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

HIGHER DIPLOMA IN MECHANICAL ENGINEERING

AUTOMOBILE AND PRIME MOVERS ENGINEERING I

(VEHICLE DYNAMICS AND CONTROL)

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Mathematical tables/Scientific calculator;
Drawing instruments.

*Answer any **FIVE** of the **EIGHT** questions in this paper.*
***ALL** questions carry equal marks.*
Maximum marks for each part of a question are as shown.

This paper consists of 4 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

1. A prototype car has a mass of 850Kg and a projected frontal area of $1.6m^2$.
As part of a development programme, one of the half shafts in the conventional live rear axle is fitted with strain gauges to measure the half shaft torque. The car is tested by driving it in a straight line, at constant speed, in low wind conditions and recording the half shaft torque. The results show that at 36Km/hr, the half shaft torque is 25.65NM and at 72Km/hr it is 43.20NM. The driving wheels have a rolling radius of 270mm and during the test, the air density was $1.2Kg/m^3$.

(a) Determine the:

(i) tractive effort at each speed;
(ii) rolling resistance and aerodynamic drag coefficient for the car.

(10 marks)

(b) If the speed is now allowed to change, calculate the time taken for the speed to rise from 72Km/hr to 108Km/hr, when climbing an incline of 7%, if the tractive effort is constant at 1200N.
Assume that the rolling resistance is constant in all the cases. (10 marks)

2. The table below gives predicted road speed 'V' and the corresponding maximum acceleration 'a' for a vehicle starting from rest in first gear.

Determine by graphical means the time taken from rest to:

(i) attain a road speed of 12m/s and;

(ii) travel a distance of 40m.

Vm/s	0	2	3	5	7	9	11	15
a-m/s²	2.25	2.42	2.52	2.78	2.82	2.74	2.6	2.24

Use the following scales:
acceleration $0.25m/s^2$ per cm;
velocity 2.5m/s per cm;
time 2.5sec per cm. (20 marks)

3. The characteristics of a tyre fitted to a driving wheel of a car can be modelled by:-
Cornering force $= 1420\,(1 - e^{-0.45\alpha})^{0.9}$ N
Traction force $= 1670\,(1 - e^{-13s})^{0.85}$ N

Where α = tyre slip angle in degrees and
s = tyre slip ratio.

Under certain cornering conditions, the tyre is transmitting a traction force of 500N and is running at a slip angle of 2^0. The driver of the car suddenly increases the traction force to 750N and maintains the lateral acceleration of the car by changing course.

Determine the:

(a) steady state slip angle of the tyre necessary to cope with the increased traction force; (11 marks)

(b) steady state driving force that will be developed in the direction of motion of the tyre; (3 marks)

(c) maximum possible traction force that can be applied to the tyre whilst still maintaining control. (6 marks)

4. The sprung mass of an experimental vehicle is 1000Kg, located 2m behind the front axle. The total ride stiffness of the front suspension is 60KN/m while that of the rear suspension is 45KN/m. If the radius of gyration of the sprung mass about a horizontal transverse axis through their mass centre is 1.732m and the wheelbase of the vehicle is 5m, determine the natural frequencies of vibration of the sprung mass.
Assume oscillatory solution. (20 marks)

5. A vehicle which has a mass of 450Kg, a wheelbase of 2.5m and a mass centre located 1.5m behind the front wheel spin axis, is travelling at a constant speed of 90Km/hr around a circular path such that its mass centre prescribes a constant radius of 200m. Effects due to load transfer and camber change can be ignored. The tyre on the equivalent single front wheel can be modelled by:-

Cornering force $= 1.8\,(-\mathrm{F})^{0.8}\,(1 - e^{-0.5\alpha})^{0.9}$

Traction force $= 1.9\,(-\mathrm{F})^{0.9}(1 - e^{-0.5\alpha})^{0.85}$

Where F = normal load on tyre (N) and α = slip angle of tyres - degrees.
Assuming that the vehicle has one front and one rear wheel and ignoring any effects due to traction, determine the:

(a) steer angle required to maintain the radius of turn; (18 marks)
(b) yaw angle of the vehicle. (2 marks)

6. A vehicle has the following specifications:

Sprung mass (distributed 45/55 front/rear)	- 800Kg
height of sprung mass centre above ground	- 300mm
rear roll centre height above ground	- 100mm
front wheel rate	- 18KN/m
rear wheel rate	- 20KN/m
wheel track	- 1.5m

Assuming independent suspensions at front and rear, working from first principles, determine:

(a) suspension rolls stiffness; (6 marks)
(b) roll compliance. (14 marks)

7. A vehicle has the following specifications:
Maximum engine speed - 6000 rev/min.
Maximum engine brake power - 30Kw at 5200 rev/min.

Engine speed at maximum torque -	3000 rev/min.
Transmission ratio range -	4284
Transmission efficiency -	84%
Drag Coefficient -	0.38
Rolling resistance coefficient -	1.8% of weight
Frontal area -	$1.9m^2$
Rolling radius of driving wheels -	270mm
Vehicle mass -	836Kg

Determine the:

(a) minimum number of gearbox ratios requried; (4 marks)

(b) theoritical numerical value of each gear ratio, assuming that an overdrive top gear ratio of 0.94:1 is to be used, and (6 marks)

(c) required axle ratio to allow the maximum achievable road speed to be reached in still air which has a density $1.23Kg/m^3$. (10 marks)

8. Part of a handling circuit on a test track consists of a right hand bend with negative 10^0. A four wheel vehicle on test has a wheel base of 2.5m. The mass centre of the vehicle is 0.8m above ground level, at mid-track 1.2m behind the front wheel spin axis and when negotiating the bend prescribes a radius of 100m.

One test involves accelerating through the bend at a constant acceleration of 0.3g. If it can be assumed that the load transfer due to cornering is shared between the front and rear axles in proportion to their static loads, determine the lowest road speed at which the inside front wheel has zero normal load. (20 marks)