BTEC HND in Mechanical Engineering

Unit / Module		Unit 08: Dynamics of Machines			
Assessment		Assignment 1: Assignment on Gears, Screw Drives, Flywheels, Cams and Universal Coupling			
Lecturer		T. P. Miyanawala			
Student Name				ID	MT/HNDME/04/___
Date Handed Over		18th July 2014	Date Due	August 2014 date will be inform soon.	
Initial Submission Date			Re-Submission Date		
Student to Tick if Attempted	Grading Opportunity	Criteria Met? Initially	Criteria Met? On Resubmission	Assessor Feedback	
	P1.1				
	P1.2				
	P1.3				
	P1.4				
	P2.1				
	M1				
	M2				
	M3				
	D1				
	D2				
	D3				
Assessed By (Name):					
Signature:			Date:		

Student Signature & Comments:

Important Information for Students

- The criteria each task relates to are shown against that task where possible.
- Please note that **plagiarism** is treated as a serious offence and therefore the work you produce **must be individual and original** although may work in groups in some instances.
- All sources of information must be **referenced using "Harvard referencing**" where a **reference list/Bibliography** should be included at the end of the assignment.
- Please note that the submission date given for this assignment is the **final date** that you can hand over the assignment.
- Assignments returned to students for re-working must be **re-submitted within 10 days**.
- **Failure to re-submit** the previously marked assignment with the re-submitted assignment will mean that **results cannot be released for the respective unit**.

Please read, follow and reference both the **contents of the unit outline** and the **grading criteria of the assignment** before completing this assignment.

Report Structure

Paper Size	A4
Printing or hand written	Single Side
Font	Times New Roman
Font size	12
Line spacing	1.5 pt
Diagrams	Where diagrams are need draw them clearly and to a sufficiently large scale.
Colours	No limitation
Presenting format	As a report. However, give brief answers in point form wherever possible.
Referencing	Use Harvard style of referencing

Plagiarism:

While research and discussion are an essential part of an assignment, the deliberate copying of someone else's work or unacknowledged copying from printed or electronic sources is NOT permitted. You may be subject to disciplinary procedure if you do this. You should sign this sheet to show that you comply with these regulations.

Student's Signature: …….. Date: ……

Student's Comments:

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Assessment has been internally verified for use.			
Internal Verifier Name:	Dr. Manjula Nanayakkara		
Signature :	Approved By: Dr. Manjula	Date Verified :	16th July, 2014

Task 01:

(P1.1) (M1)

It is required to design and assemble a planetary gear box for the operation of a machine in a production plant. The only annular wheel available contains 60 teeth and it has a modulus of 1 mm. The operation of the machine requires two output shafts from the gear box. When one output shaft is engaged, the other one is put to rest using clutches. The velocity ratios required by the two outputs are as follows.

$$1 < Velocity\ Ratio_1 < 2 \quad and \quad 5 < Velocity\ Ratio_2 < 6$$

i) Determine the velocity ratios that can be achieved by the gear box in terms of number of teeth in the sun wheel (t_s).

ii) Determine which component (out of the sun wheel, planet carrier and annular wheel) has to be used as the input shaft to get the required velocity ratios. Explain the reasons for your selection.

iii) Calculate the possible values for the number of teeth in sun wheel. Obtain the values for number of teeth in planetary wheels for each case and conclude the only possible value for the number of teeth in the sun wheel.

iv) One output shaft of the gear box is coupled to a gear wheel with 20 teeth and Moment of Inertia of 1 kgm^2. This wheel is meshed with another gear to get a velocity ratio of 1:4. This second gear has a Moment of Inertia of 5 kgm^2. Calculate the torque that should be exerted by the output shaft to obtain an angular acceleration of 6 rad/s^2.

Task 02:

(P1.2) (D1)

A screw jack has a thread diameter of 30 mm and a 6 mm pitch. The handle used is 500 mm long. If the friction coefficient is 0.15;

i) Calculate the velocity ratio and force ratio when a load is lifted.

ii) Calculate the mechanical efficiency of the screw jack.

iii) It is suggested to design a screw thread to obtain maximum efficiency for the jack. Calculate the helix angle which gives the maximum efficiency for the screw jack with the same friction coefficient. Discuss the drawbacks if this screw thread is to be used in a screw jack.

Task 03:

(P1.3)

A turning moment diagram for a single cylinder four stroke engine is drawn. The scaled drawing indicates following areas around the mean torque line.

Exhaust stroke = 650 mm^2, Suction stroke = 400 mm^2, Compression stroke = 1500 mm^2

i) Calculate the area of the diagram for the power stroke above the mean torque line.

ii) Each 1 mm^2 represents 3 J. If the engine rpm has to be maintained between 198 and 202, calculate the Moment of Inertia of the flywheel.

iii) If the mass of the flywheel is 24 kg calculate the radius of gyration.

Task 04:

(P1.4)

i) Explain how Hooke's joints are used in automotive transmission systems specifically highlighting the use of two Hooke's joints in a single shaft.

ii) For any fixed angle between shafts, what is/are the rotation angle(s) which give(s) the maximum velocity ratio? Support your answer with a direct proof.

iii) On the same graph plot the fluctuation of the velocity ratio of a Hooke's joint when the angles between the shafts are 15^0, 30^0, 45^0 and 60^0 and comment on the maximum and minimum speed fluctuation.

Task 05:

(P2.1)

A constant acceleration cam has to be designed such that it gives a 20 mm rise to a flat foot follower within the motion of 70^0. This rise should contain equal acceleration and deceleration. Then it should dwell for 60^0 and fall in the same manner. If the rotation speed of the cam is 60rev/min;

i) Calculate the constant acceleration of the rise.

ii) Clearly stating the steps followed, draw the cam profile if the base circle radius is 80 mm. (You may use manual methods or CAD software, but clearly indicate the construction lines. If CAD software is used, a properly generated drawing should be attached; screenshots are not accepted.)

Task 06:

(P2.2) (M2)

An internal combustion engine drives a slider-crank mechanism which has a crank length of 50 mm and connecting rod length of 170 mm. The constant rotation speed of the crankshaft is 300 rev/min.

i) Derive equations for the velocity and acceleration of the slider (piston) assuming that the crank length is small compared to the connecting rod.

ii) Calculate the angular velocity and acceleration of the connecting rod when the rotation angle is 40^0 using relative motion vector diagrams.

iii) Draw the mechanism to a scale and use the instantaneous centre and Klein's construction and determine the quantities calculated in (ii). Compare your results and comment on them.

iv) The equivalent piston mass is 3 kg. Plot the variation of the primary force and secondary force with the rotation angle of the crank in the same graph. Comment on the significance of each of the forces.

Task 07:

(P2.3)

The rotor blades of a helicopter have a moment of inertia of 40 kgm^2 about the vertical axis. These blades are brought to rest from its maximum angular velocity of 100 rev/min, at a constant angular acceleration in 15 seconds. In the meantime, the pilot gives it a constant angular acceleration around longitudinal axis starting from rest and until it reaches 2 rev/min in 15 seconds.

i) Plot the graphs of

   a. Angular velocity of blades vs. time

   b. Longitudinal angular velocity of the helicopter vs. time

ii) Obtain a graph for the gyroscopic torque applied on the helicopter vs. time and find its maximum value. In a clear sketch show the direction of rotation of the blades and helicopter and the direction of the gyroscopic torque. Explain the effect of this torque on the system.

Task 08:

(P3.1) (P3.3) (P3.4) (D3)

The suspension system of a wheel of an automotive is represented by a spring mass system as shown in Figure 1.

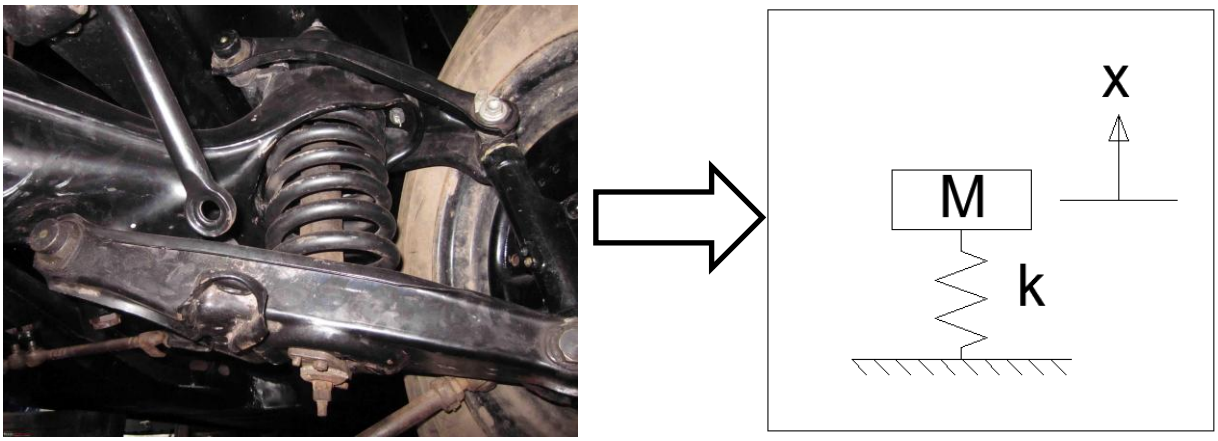

Figure 1: Automotive suspension system modelled by a spring and mass system. (Suspension system is of Mercedes Benz "Ponton". Source: (TEAM-BHP))

i) Derive the equation for the natural frequency of the system.

ii) Give a design to replace this spring arrangement with a torsional rotor-shaft arrangement using Solidworks. (The hardcopy of the design is sufficient)

iii) It is required to select a suitable dashpot (damper) for the arrangement mentioned in (i). The mass of the automotive is 1000 kg and is supposed to carry 4 passengers with a weight 75 kg each. Assuming that the weight exerted on the arrangement is ¼th of the total weight, calculate the critical damping coefficient for the system. (Stiffness coefficient of the spring is 300 Nm^{-1})

iv) A damper with a damping coefficient equal to the critical damping coefficient calculated in (iii) was installed to the arrangement. Describe the vibration pattern of the system. Determine the effect, of adding an extra passenger weighing 75 kg, on the vibration pattern.

v) The arrangement mentioned in (iv) [5 passengers and the vehicle with the spring and designed damper] is in motion in a wavy road. The effect of the road is modelled by a sinusoidal ground excitation as shown in Figure 2. Derive equations for the amplitude and phase shift of the vehicle vibration in terms of angular velocity of the excitation function (ω). Find the angular velocity which gives the

maximum amplitude. (Amplitude of road displacement function, i.e. the excitation function is 0.025m)

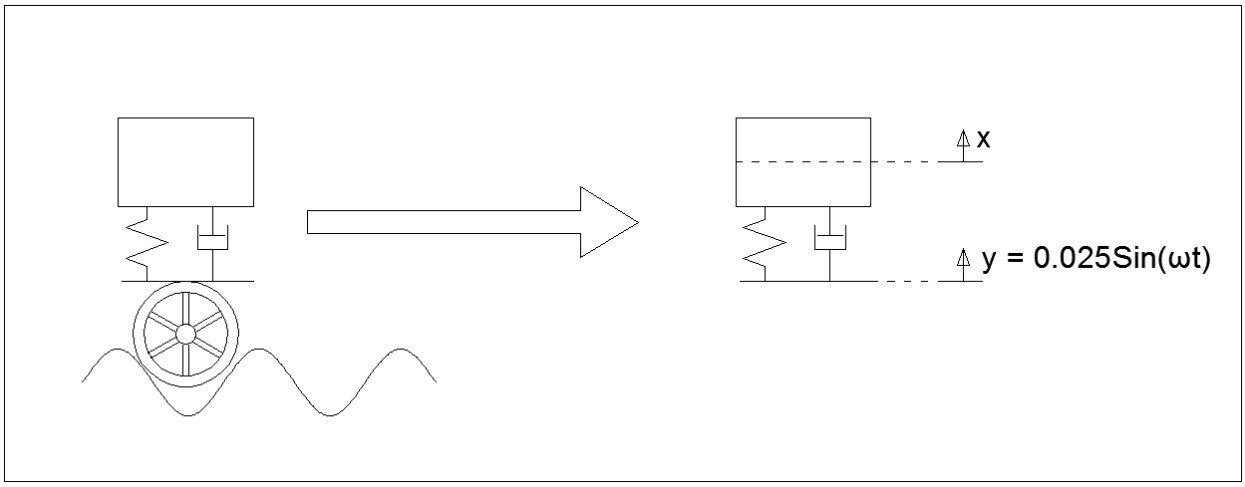

Figure 2: Motion on the wavy road is modelled by a sinusoidal excitation

Task 09:

(P3.2)

An 8 mm diameter cylindrical shaft is made out of AISI 1015 cold drawn steel. This shaft is 1m long and is simply supported at its ends. Find the lowest critical whirling speed of this shaft.

(Mention the required material properties with the source(s) of information. Validity of the source(s) is evaluated.)

Bibliography

TEAM-BHP. *Suspension of Mercedes Benz Ponton*. Mercedes Benz.

UNIT 08: Dynamics of Machines
Learning outcomes and assessment criteria

Learning outcomes On successful completion of this unit a learner will:	Assessment criteria for pass The learner can:	You need to
01 Analyze the kinetic and dynamic characteristics of power transmission system elements	1.1 Analyze geared systems to determine velocity ratio and required accelerating torque	Calculate the required values asked in Task 1
	1.2 determine the operating efficiency of screw jacks and lead screws	Obtain values for the questions asked in Task 2
	1.3 Analyze turning moment diagrams for reciprocating engines and presses to determine the required flywheel parameters for specific operating conditions	Solve the problems in Task 3
	1.4 Analyze the characteristics of Hooke's joints and constant velocity joints and recognize the conditions for a constant velocity ratio	Answer the questions in Task 4 in a proper analytic manner
02 Analyze the kinetic and dynamic characteristics of mechanisms	2.1 Determine the output motion of radial plate and cylindrical cams	Perform Task 5
	2.2 Determine the velocities and accelerations of points within plane mechanisms and the associated inertia forces	Calculate the values requested in Task 6
	2.3 Analyze systems in which gyroscopic motion is present to determine the magnitude and effect of gyroscopic reaction torque	Calculate the requested values in Task 7 and elaborate the answer for Task 7 (ii)
03Be able to determine the behavioural characteristics of translational and	3.1 Determine the natural frequency of vibration in translational and rotational mass-spring systems	Perform Task 8 (i)

rotational mass-spring systems	3.2 Determine the critical whirling speed of shafts	Perform Task 9
	3.3 Determine the transient response of damped mass-spring systems when subjected to a disturbance	Perform Task 8 (iii) and Task 8 (iv)
	3.4 Determine the steady state response of damped mass-spring systems when subjected to sinusoidal excitation.	Perform Task 8 (v)

Merit/Distinction Grade: Merit/Distinction Grade is achieved by meeting all following Grade Descriptors

Merit descriptors	**Indicative characteristics**	**Contextualised Evidence/Examples**
In order to achieve a **Merit** the learner must:	The learner's evidence shows:	To achieve the grade you will need to:
M1 identify and apply strategies to find appropriate solutions	• **Effective judgments have been made** • **Complex problems with more than one variable have been explored** • An effective approach to study and research has been applied	Demonstrate logical approach in designing the gear box in Task 1
M2 select/design and apply appropriate methods/techniq ues	• **Relevant theories and techniques have been applied** • A range of methods and techniques have been applied • A range of sources of information has been used • The selection of methods and techniques/sources has been justified the design of methods/techniques has been justified • Complex information/data has been synthesised and processed appropriate learning methods/techniques have been applied	In Task 6 find the velocities and accelerations using both theoretical calculations and geometrical approaches. Critically compare and comment on the results.
M3 present and communicate appropriate	• **The appropriate structure and approach has been used** • Coherent, logical development of	Maintain uniform style and format throughout

findings	principles/concepts for the intended audience • A range of methods of presentation have been used and technical language has been accurately used • Communication has taken place in familiar and unfamiliar contexts • The communication is appropriate for familiar and unfamiliar audiences and appropriate media have been used	this submission. Strictly adhere to the relevant report style. Mention on use of Harvard style, binding instructions, and contents and the format.
Distinction descriptors	**Indicative characteristics**	**Contextualised Evidence/Examples**
In order to achieve a **distinction** the learner must:	The learner's evidence shows:	To achieve the grade you will need to:
D1 use critical reflection to evaluate own work and justify valid conclusions	• **Conclusions have been arrived at through synthesis of ideas and have been justified** • The validity of results has been evaluated using defined criteria • Self-criticism of approach has taken place • Realistic improvements have been proposed against defined characteristics for success	Justify the design in Task 2 (ii) with regard to theoretical and practical aspects.
D2 take responsibility for managing and organizing activities	• **Autonomy/independence has been demonstrated** • Substantial activities, projects or investigations have been planned, managed and organized • Activities have been managed • The unforeseen has been accommodated • Importance of interdependence has been recognized and achieved	Demonstrate autonomy/independence throughout this submission
D3 demonstrate convergent/lateral /creative thinking	• ideas have been generated and decisions taken • self-evaluation has taken place • convergent and lateral thinking have been applied • **problems have been solved** • **innovation and creative thought have been applied** • receptiveness to new ideas is evident • **effective thinking has taken place in unfamiliar contexts.**	Complete Task 8 demonstrating correct analytical approach for Task 8 (i), (iii), (iv) and (v). Design practical solution(s) for Task 8 (ii).

Grading Matrix

	Assignment 1	Examination
P1.1	✓	
P1.2	✓	
P1.3	✓	
P1.4	✓	
P2.1	✓	
P2.2	✓	
P2.3	✓	
P3.1	✓	
P3.2	✓	
P3.3	✓	
P3.4	✓	
M1	✓	
M2	✓	
M3	✓	
D1	✓	
D2	✓	✓
D3	✓	