PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING: MECHANICAL TECHNOLOGY*
SUBJECT	:	**MECHANICS OF MACHINES 3**
CODE	:	**EMM313**
DATE	:	NOVEMBER EXAMINATION 18 NOVEMBER 2014
DURATION	:	(Y-PAPER) 12:30 - 15:30
WEITHT	:	40 :60
FULL MARKS	:	90
TOTAL MARKS	:	94

ASSESSOR	:	MR P STACHELHAUS
MODERATOR	:	D IONESCU 2187
NUMBER OF PAGES	:	4 PAGES AND 1 ANNEXURE

INSTRUCTIONS:

- AN A3 PORTABLE DRAWING BOARD OR DRAFTING HEAD MAY BE USED.
- A CALCULATOR OF ANY MAKE OR MODEL IS PERMITTED.

REQUIREMENTS:

- NIL

INSTRUCTIONS TO STUDENTS:

- IT WILL BE EXPECTED THAT THE STUDENT MAKES REASONABLE ASSUMPTIONS FOR DATA NOT SUPPLIED.
- NUMBER YOUR QUESTIONS CLEARLY AND UNDERLINE THE FINAL ANSWER.
- ANSWERS WITHOUT UNITS WILL BE IGNORED.
- ALL DIMENSIONS ON DIAGRAMS ARE IN mm UNLESS OTHERWISE SPECIFIED.

QUESTION 1 INERTIA

Two cylinders of the same outside diameter, length and material are placed side by side on an inclined plane with an inclination of 10° to the horizontal. One of the cylinders is hollow, the inside diameter being 0.9 times that of the outside diameter. The other cylinder is solid. The hollow cylinder is allowed to begin rolling down the incline 1 second before the solid cylinder is released. Assume that there is no slip and that the inclined plane is sufficiently long. Determine:

1.1 how far the cylinders move down the slope before they are side by side again, and (17)

1.2 the velocity of each cylinder at the instant they are side by side. (5)

[22]

QUESTION 2 BELT-DRIVES

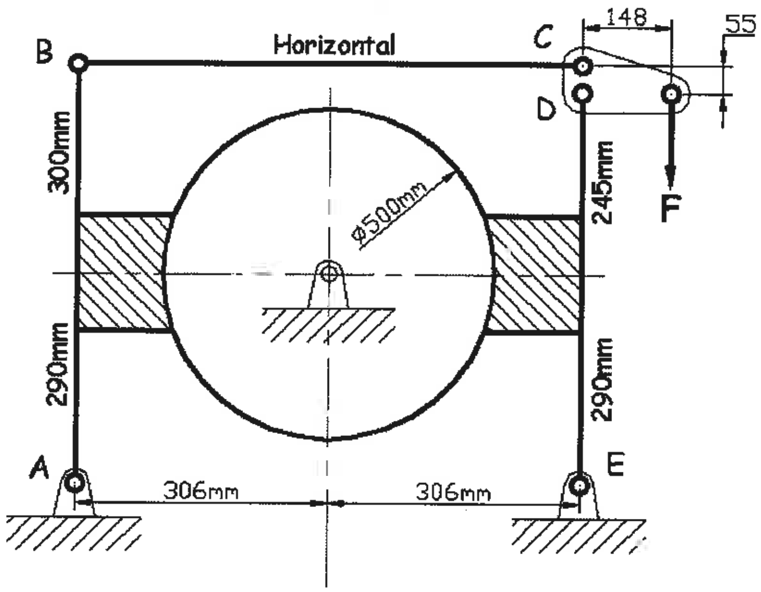
Power is transmitted from an electric motor to a machine by an open V-belt which has a 40° included groove angle. The V-belt material has a mass of 0.45 kg/m and a maximum allowable tension of 800 N. The coefficient of friction between the belt and pulleys is 0.3. The motor rotates at 1200 r/min and has a pulley of 200 mm effective diameter. The center distance between the pulleys is 900 mm. The machine is to rotate at one third of the speed of the motor.

2.1 Determine the initial belt tension and maximum power which can be transmitted for the conditions stated above. (14)

2.2 If the motor speed can be increased, determine the maximum theoretical power which can be transmitted. (5)

[19]

QUESTION 3 RIGIDLY MOUNTED BLOCK BRAKE SYSTEM

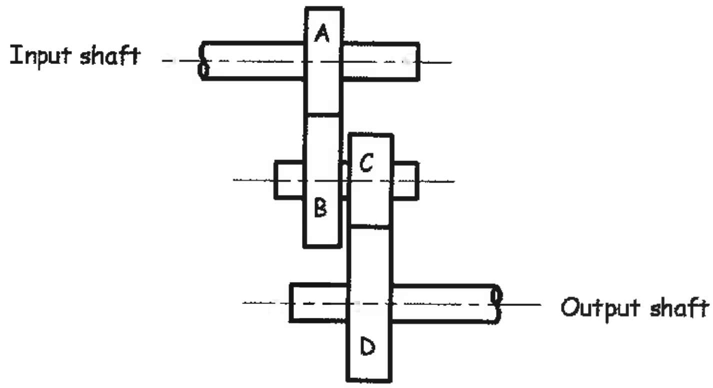


Calculate the force F that has to be applied at the (CDF) in order to obtain a braking torque of 1755 Nm for a clockwise rotating drum. Each block is rigidly fixed to the lever and the coefficient of friction is 0.32 at the brake drum.

[18]

QUESTION 4 **GEAR SYSTEMS**

The figure shows a geared system with an input shaft and gear A, an intermediate compound gear with wheels B and C rigidly connected, which drives an output gear and shaft D. Gear A meshes with B, and C meshes with D. A power source of 15 kW at 2100 r/min is applied to the input shaft. The efficiency of each gear pair is 98%. Each gear has the following details:



Gear A:	24 teeth;	module 8
Gear B:	40 teeth;	module 8
Gear C:	18 teeth;	module 10
Gear D:	48 teeth;	module 10

Calculate:

4.1 The center distance AB and BD.

4.2 The torque at the output shaft.

4.3 The gearing ratio between input and output shaft.

[15]

QUESTION 5 **BALANCING**

A rotating shaft AD is 0.9 m long and carries rotating masses of 15 kg, 20 kg, 15 kg and 10 kg at points A, B, C and D respectively, spaced at equal intervals along the shaft. The mass centers are 5 mm, 7.5 mm, 10 mm and 7.5 mm from the axis of rotation for A, B, C and D respectively. The mass center for mass D is at 180° to that of mass A. If the shaft can be completely balanced by a mass M at a radius of 50 mm in the plane of mass D, determine the relative angular positions of the masses, and the value of M and its angular setting to give complete balance.

[20]

TOTAL : 94

ANNEXURE 1

FORMULA SHEET

	Rotation	Translation
Relationship	$s = r\theta \quad ; \quad v = r\omega \quad ; \quad a = r\alpha$	
Torque	$T = I \cdot \alpha$	$F = m \cdot a$
Energy	$K.E. = \frac{1}{2} \cdot I \cdot \omega^2$	$K.E. = \frac{1}{2} \cdot m \cdot v^2$
	$Work\ done = T \cdot \theta$	$Work\ done = F \cdot d$
	$P.E. = none$	$P.E. = m \cdot g \cdot h$
Power	$P = T \cdot \omega$	$P = F \cdot v$
Momentum	$M = I \cdot \omega$	$M = m \cdot v$
Equations of motion	$\omega_i = \omega_o + \alpha \cdot t$	$v = u + a \cdot t$
	$\theta = \omega \cdot t + \frac{1}{2} \cdot \alpha \cdot t^2$	$s = u \cdot t + \frac{1}{2} \cdot a \cdot t^2$
	$\omega_i^2 = \omega_o^2 + 2 \cdot \alpha \cdot \theta$	$v^2 = u^2 + 2 \cdot a \cdot s$

General Mechanics 2 formulae

$$Energy\ at\ datum\ 1 = Energy\ at\ datum\ 2 + Work\ Done\ against\ friction$$

$$(mgh)_1 + \left(\frac{1}{2}mv^2\right)_1 + \left(\frac{1}{2}I\omega^2\right)_1 = (mgh)_2 + \left(\frac{1}{2}mv^2\right)_2 + \left(\frac{1}{2}I\omega^2\right)_2 + F_f \cdot d + T_f \cdot \theta$$

$$P = (T_1 - T_C)\left(1 - \frac{1}{e^{\mu\theta}}\right) v$$

$$T_C = \dot{m} \cdot v^2$$

$$\frac{T_1 - T_C}{T_2 - T_C} = e^{\mu \cdot \theta}$$

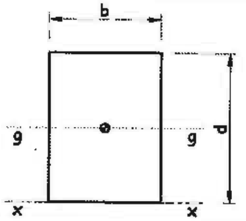
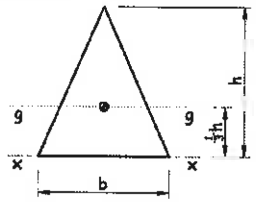
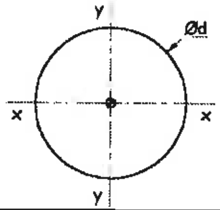
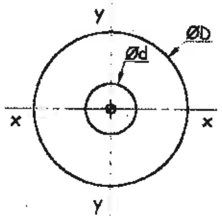
$$\frac{T_1}{T_2} = \left[\frac{1 + \mu \cdot \tan\theta}{1 - \mu \cdot \tan\theta}\right]^n$$

$$\mu = \tan\emptyset$$

$$x = r \cdot \sin\emptyset$$

$$\frac{\sin\alpha}{r} = \frac{\sin\theta}{(r + c)} = \frac{\sin(180^\circ - \emptyset)}{(r + c)}$$

ANNEXURE 2

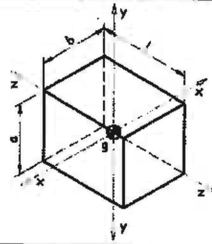
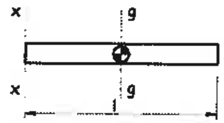
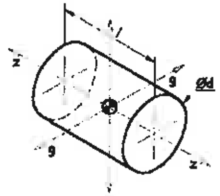
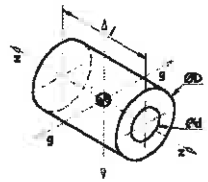
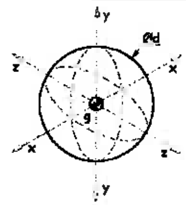
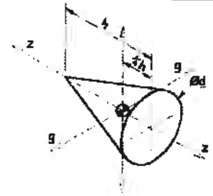
SECOND MOMENT OF MASS OF LAMINAE			
Figure	Area	Centre of gravity	Moment of Inertia
	$A = b \cdot d$	$\frac{1}{2}b$ & $\frac{1}{2}d$	$I_x = \frac{m \cdot d^2}{3}$ $I_g = \frac{m \cdot d^2}{12}$
	$A = \frac{1}{2} \cdot b \cdot d$	$\frac{1}{3}h$ from base	$I_x = \frac{m \cdot h^2}{6}$ $I_x = \frac{m \cdot h^2}{18}$
	$A = \frac{\pi}{4} \cdot d^2$	Centre	$I_x = I_y = \frac{m \cdot d^2}{16}$
	$A = \frac{\pi}{4}(D^2 - d^2)$	Centre	$I_x = \frac{m(D^2 + d^2)}{16}$

Definition: $I_x = \int y^2 \cdot dm$

Parallel axis theorem: $I_o = I_g + m \cdot h^2$

In general $I = m \cdot k^2$

Perpendicular axis theorem: $I_z = I_x + I_y$ *(Laminae only)*

SECOND MOMENT OF MASS OF SOLID BODIES		
Type of body	Volume	Moment of Inertia
	$V = a \cdot b \cdot l$	$I_x = \frac{m}{12}(a^2 + l^2)$ $I_y = \frac{m}{12}(b^2 + l^2)$ $I_z = \frac{m}{12}(a^2 + b^2)$
Slender rod – of any x-section 	$V = area \times l$	$I_x = \frac{m \cdot l^2}{3}$ $I_g = \frac{m \cdot l^2}{12}$
	$V = \frac{\pi}{4} \cdot d^2 \cdot l$	$I_z = \frac{m \cdot d^2}{8}$ $I_g = m\left(\frac{d^2}{16} + \frac{l^2}{12}\right)$
	$V = \frac{\pi}{4} \cdot (D^2 - d^2) \cdot l$	$I_z = \frac{m}{8}(D^2 + d^2)$ $I_g = m\left(\frac{D^2}{16} + \frac{d^2}{16} + \frac{l^2}{12}\right)$
	$V = \frac{\pi \cdot d^3}{6}$	$I_x = I_y = I_z = \frac{m \cdot d^2}{10}$
	$V = \frac{1}{3} \times \frac{\pi}{4} \cdot d^2 \cdot h$	$I_z = \frac{3 \cdot m \cdot d^2}{40}$ $I_g = \frac{3 \cdot m}{80} \cdot \left(\frac{d^2}{16} + \frac{l^2}{12}\right)$