UNIVERSITY
OF
JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING: MECHANICAL TECHNOLOGY*
SUBJECT	:	**MECHANICS OF MACHINES 2**
CODE	:	**EMM2111**
DATE	:	SUMMER EXAMINATION 2015 24 NOVEMBER 2015
DURATION	:	(SESSION 2) 12:30 - 15:30
WEITHT	:	40 :60
FULL MARKS	:	100
TOTAL MARKS	:	100

ASSESSOR	:	MR P STACHELHAUS	
MODERATOR	:	DR L MTHEMBU	2187
NUMBER OF PAGES	:	4 PAGES AND 2 ANNEXURES	

INSTRUCTIONS:

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

REQUIREMENTS:

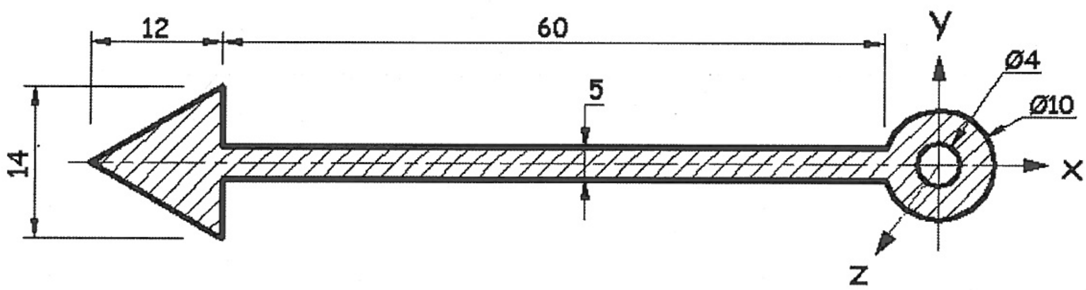
- NIL

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.

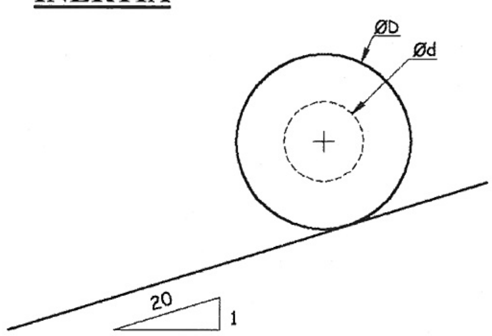
QUESTION 1 INERTIA

The needle gauge shown, rotates about its polar axis (i.e. the z-axis). Treat it as a laminae of density $\rho = 1.53$ kg/m^2. Determine the second moment of mass about the axis of rotation.



[28]

QUESTION 2 INERTIA



A hollow sphere is allowed to roll down an incline of 1 in 20. Its outside diameter **D** is equal to twice the inside diameter **d**. Assume there is no slip and hence determine its acceleration.

[12]

QUESTION 3 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 pulley is to rotate at one third the speed of the motor pulley.

3.1 Determine:

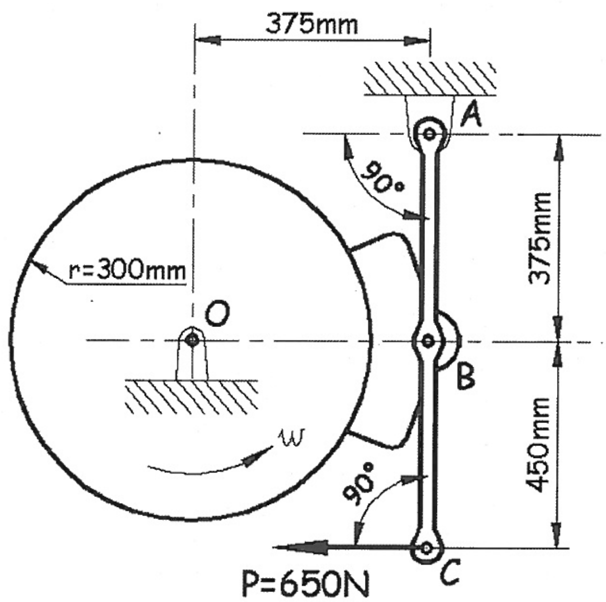
3.1.1 the initial belt tension, and (9)

3.1.2 the maximum power which can be transmitted for the conditions stated above. (2)

3.2 If the motor speed can be increased, determine the maximum theoretical power which can be transmitted. (4)

[15]

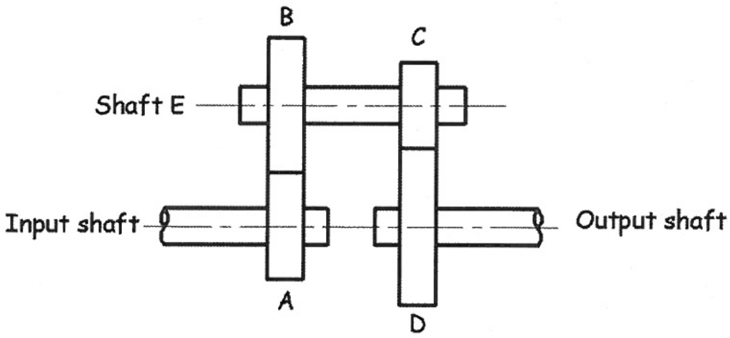
QUESTION 4 RIGIDLY MOUNTED BLOCK BRAKE SYSTEM



The above figure depicts a pivot block brake. It is activated by lever ABC. The coefficient of friction between the drum and brake shoe is 0.7. A force of 650 N applied to the lever, causes an angular retardation of 8.65 rad/s^2 on an anticlockwise rotating drum. Calculate the second moment of mass of the brake drum.

[15]

QUESTION 5 GEAR SYSTEM GEOMETRY



A reverted gear train is shown in the figure. Gear A is driving gear D through gears B and C so that the maximum velocity ratio $\frac{N_a}{N_d} = 12$ and the ratio of each reduction is the same.

Gear B and gear C are compound gears fixed on the shaft E. Gears A and B have a module of 4 and gears C and D have a module of 9.

If gear C has 16 teeth, determine:

5.1 The number of teeth of gears A, B and D and the actual reduction ratios; (11)

5.2 The center distance between the shafts. (3)

[14]

QUESTION 6 BALANCING

A shaft carries four eccentric masses, A, B, C and D, placed in that order along its axis. Mass A is 7 kg at a radius of 300 mm from the shaft axis. Mass B is at a radius of 420 mm from the shaft axis. Mass C is 4 kg at a radius of 400 mm from the shaft axis. Mass D is 3 kg at a radius of 450 mm from the shaft axis. The planes of revolution of masses A and B are 400 mm apart and those of B and C are 450 mm apart. The radii of masses A and C are at right angles to each other.

Determine for dynamic balance:

6.1 the angular positions of masses B and D relative to A.
(Useful scales: 1 mm = 0.01 kg·m^2 and 2 mm = 0.05 kg·m). (9)

6.2 the distance between planes C and D. (2)

6.3 the mass of B. (5)

[16]

TOTAL : 100

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	$\omega_i = \omega_o + \alpha \cdot t$	$v = u + a \cdot t$
	$\theta = \omega \cdot t + \frac{1}{2} \cdot \alpha \cdot t^2$	$s = u \cdot t + \frac{1}{2} \cdot a \cdot t^2$
	$\omega_i^2 = \omega_o^2 + 2 \cdot \alpha \cdot \theta$	$v^2 = u^2 + 2 \cdot a \cdot s$

Conservation of energy:

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

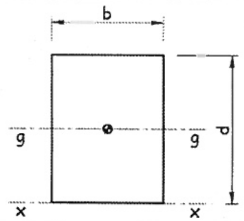
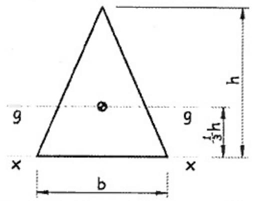
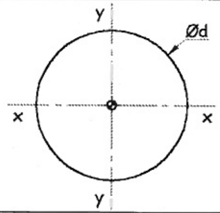
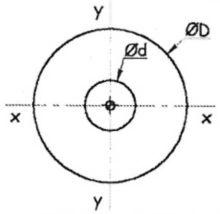
$$(mgh)_1 + \left(\frac{1}{2}mv^2\right)_1 + \left(\frac{1}{2}I\omega^2\right)_1 = (mgh)_2 + \left(\frac{1}{2}mv^2\right)_2 + \left(\frac{1}{2}I\omega^2\right)_2 + F_f \cdot d + T_f \cdot \theta$$

More useful formulae:

Belt-tension ratio	$\frac{t_1 - t_C}{t_2 - t_C} = e^{\mu \cdot \theta}$
Belt power	$P = (t_1 - t_C)\left(1 - \frac{1}{e^{\mu\theta}}\right)v$
Effect of belt-mass	$t_C = \dot{m} \cdot v^2$
Block-brake tension ratio	$\frac{t_1}{t_2} = \left[\frac{1 + \mu \cdot \tan\theta}{1 - \mu \cdot \tan\theta}\right]^n$
Friction circle	$x = r \cdot \sin\emptyset$
Sin rule for pivoted brakes	$\frac{\sin\alpha}{r} = \frac{\sin\theta}{(r+c)} = \frac{\sin(180° - \emptyset)}{(r+c)}$

ANNEXURE 2

SECOND MOMENT OF MASS OF LAMINAE

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

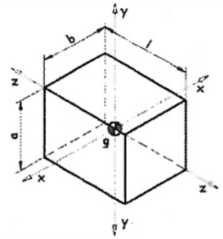
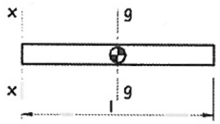
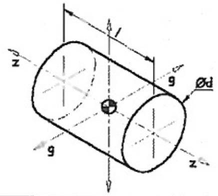
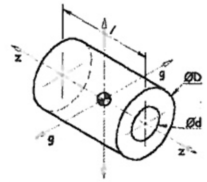
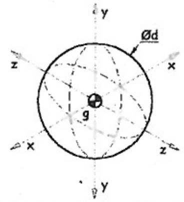
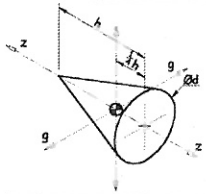
Definition: $I_x = \int y^2 \cdot dm$

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 	$V = area \times l$	$I_x = \frac{m \cdot l^2}{3}$ $I_g = \frac{m \cdot l^2}{12}$
	$V = \frac{\pi}{4} \cdot d^2 \cdot l$	$I_z = \frac{m \cdot d^2}{8}$ $I_g = m\left(\frac{d^2}{16} + \frac{l^2}{12}\right)$
	$V = \frac{\pi}{4} \cdot (D^2 - d^2) \cdot l$	$I_z = \frac{m}{8}(D^2 + d^2)$ $I_g = m\left(\frac{D^2}{16} + \frac{d^2}{16} + \frac{l^2}{12}\right)$
	$V = \frac{\pi \cdot d^3}{6}$	$I_x = I_y = I_z = \frac{m \cdot d^2}{10}$
	$V = \frac{1}{3} \times \frac{\pi}{4} \cdot d^2 \cdot h$	$I_z = \frac{3 \cdot m \cdot d^2}{40}$ $I_g = \frac{3 \cdot m}{80} \cdot \left(\frac{d^2}{16} + \frac{l^2}{12}\right)$