School of Mechanical and Manufacturing Engineering

MMAN1300 – ENGINEERING MECHANICS 1

FINAL EXAM 2018 S2

Student Name: ☞	
Student ID: ☞	

Instructions:

- Time allowed: 120 minutes
- Total number of questions: 12
- Answer all the questions in the exam – you should aim to spend 10 minutes per question.
- Answer all questions in the spaces provided
- The 48 marks allocated are worth 40% of the course overall
- Mark your name, student ID and all other requested details above
- Record your answers (with appropriate units) in the ***ANSWER BOXES*** provided
- You may bring a University approved calculator

Notes:

Your work must be complete, clear and logical

Do not skip steps, sign conventions, units and relevant diagrams and clearly state the final answers

No part of this paper is to be retained by candidates

Question 1: Vectors and Forces	(4 Marks)
Question 2: FBDs and Equilibrium	(4 Marks)
Question 3: Structures and Trusses	(4 Marks)
Question 4: Frames and Machines	(4 Marks)
Question 5: Distributed Loads, Shear Force and Bending Moments	(4 Marks)
Question 6: Centroids and Moment of Inertia	(4 Marks)
Question 7: Particle Kinematics	(4 Marks)
Question 8: Particle Kinetics	(4 Marks)
Question 9: Work-Energy Methods for Particles	(4 Marks)
Question 10: Kinematics of Rigid Bodies	(4 Marks)
Question 11: Kinetics of Rigid Bodies	(4 Marks)
Question 12: Work-Energy Methods for Rigid Bodies	(4 Marks)

Equation Sheet

Rectilinear motion

$$v = \frac{ds}{dt} \qquad a = \frac{dv}{dt} \qquad vdv = ads$$

Constant linear acceleration equations ($t_o = 0$)

$$v = v_o + at \qquad v^2 = v_o^2 + 2a(s - s_o) \qquad s = s_o + v_o t + \tfrac{1}{2}at^2$$

Angular motion

$$\omega = \frac{d\theta}{dt} \qquad \alpha = \frac{d\omega}{dt} \qquad \omega d\omega = \alpha d\theta$$

Displacement, velocity and acceleration components

Rectangular coordinates

$$\mathbf{r} = x\mathbf{i} + y\mathbf{j} \qquad \mathbf{v} = \dot{x}\mathbf{i} + \dot{y}\mathbf{j} \qquad \mathbf{a} = \ddot{x}\mathbf{i} + \ddot{y}\mathbf{j}$$

Normal and tangential coordinates

$$\mathbf{v} = v\mathbf{e_t} \qquad \mathbf{a} = a_t\mathbf{e_t} + a_n\mathbf{e_n} \qquad v = \omega r \qquad a_t = \dot{v} = \alpha r \qquad a_n = v^2/\rho = \omega^2 r$$

Relative motion

$$\mathbf{r}_A = \mathbf{r}_B + \mathbf{r}_{A/B} \qquad \mathbf{v}_A = \mathbf{v}_B + \mathbf{v}_{A/B} \qquad \mathbf{a}_A = \mathbf{a}_B + \mathbf{a}_{A/B}$$

Equation of motion (Newton’s 2nd law)

$$\sum \mathbf{F} = m.\mathbf{a}$$

Work-Energy

$$W_{1-2} = \Delta T + \Delta V_g + \Delta V_e$$

$W_{1-2} = F\Delta s$ and/or $M\Delta\theta$

$\Delta T = \frac{1}{2}m\left(v_2^2 - v_1^2\right)$ and/or $\frac{1}{2}I\left(\omega_2^2 - \omega_1^2\right)$

$$\Delta V_g = mg(h_2 - h_1)$$

$\Delta V_e = \frac{1}{2}k\left(x_2^2 - x_1^2\right)$ for a linear spring

For a rigid body in plane motion

$$\sum \mathbf{F} = m\mathbf{a} \qquad \sum \mathbf{M}_G = I_G\boldsymbol{\alpha}$$

Mass moment of inertia

$I = \int r^2 dm$, $\quad I_O = I_G + md^2 \quad (d$ = distance $OG)$

Disc/cylinder: $I_G = \frac{1}{2}mr^2$, Slender rod: $I_G = \frac{1}{12}ml^2$

Centroid of a cross-section:

$$\bar{x} = \frac{\int x\,dA}{\int dA} = \frac{\sum x_i A_i}{\sum A_i}, \qquad \bar{y} = \frac{\int y\,dA}{\int dA} = \frac{\sum y_i A_i}{\sum A_i}$$

DATA: g = 9.81 m/s^2

Transformation Equations

$$I_{uu} = \frac{I_{xx} + I_{yy}}{2} + \frac{I_{xx} - I_{yy}}{2}\cos 2\theta - I_{xy}\sin 2\theta$$

$$I_{vv} = \frac{I_{xx} + I_{yy}}{2} - \frac{I_{xx} - I_{yy}}{2}\cos 2\theta + I_{xy}\sin 2\theta$$

$$I_{uv} = \frac{I_{xx} - I_{yy}}{2}\sin 2\theta + I_{xy}\cos 2\theta$$

$$I_{11,22} = \frac{I_{xx} + I_{yy}}{2} \pm \sqrt{\left(\frac{I_{xx} - I_{yy}}{2}\right)^2 + {I_{xy}}^2}$$

Parallel Axis Theorem

$$(I_{xx})_o = (I_{xx})_G + A{d_y}^2$$

$$\left(I_{yy}\right)_o = \left(I_{yy}\right)_G + A{d_x}^2$$

$$\left(I_{xy}\right)_o = \left(I_{xy}\right)_G + Ad_x d_y$$