NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY

MECHANICAL ENGINEERING

SCH 2205

Second Semester Examination Paper

May 2015

This examination paper consists of 7 pages

Time Allowed: 3 hours
Total Marks: 100
Special Requirements: Calculator, Trigonometry tables (attached)
Examiner's Name: Mr Golden G Nyambuya

INSTRUCTIONS TO CANDIDATES

Answer <u>ANY FIVE</u> questions. Each question carries 20 marks.
Make use of clear sketches where necessary.

MARK ALLOCATION

QUESTION	MARKS
1.	20
2.	20
3.	20
4.	20
5.	20
6.	20
TOTAL POSSIBLE MARKS	100

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1. (a) A displacement vector lying in the *x-y* plane has magnitude 5m and makes an angle of 60^0 with the *x*-axis. Find its *x* and *y* components.   [2 marks]

    (b) A ship at sea receives radio signals from two radio transmitters A and B 125 m apart, one due south of the other. The direction finder shows that transmitter A is 30^0 south of east, while transmitter B is due east.

    (i)   Draw a sketch showing the point locations of A, B and the ship
    (ii)   Determine the distance of the ship from each transmitter.   [2+2 marks]

    (c) Suppose that a ball is thrown vertically upward with an initial velocity of 25m/s. Determine:

    (i)   How high it will go,
    (ii)   What velocity it will have as it moves down past its original point of projection,
    (iii) Its position 6 sec after it was thrown upwards, and
    (iv)   The velocity with which it will be moving at this time.

    [2+2+2+2 marks]

    (d) The angular velocity of an airplane propeller is increased from 1 800 rpm to 2 200 rpm in 10 sec. Determine:

    (i)   Its angular acceleration (in rad/s^2)
    (ii)   The angle traversed this period (in radians)   [3+3 marks]

2. Solve the following problems:
    (a) A force of 800N is applied to a mass of 160kg. Determine:

    (i)   The acceleration produced.
    (ii)   If the body starts from rest, determine the distance the body travels if the force acts on it for 12 sec.

    [2+2 marks]

(b) A weight of 80kg rests on a smooth plane which is inclined at an angle of 37^0 with the horizontal, as shown in the figure below. Calculate:

    (i) The normal force on the body
    (ii) The magnitude of the horizontal force which will keep the block from sliding down the plane.   [2+2 marks]
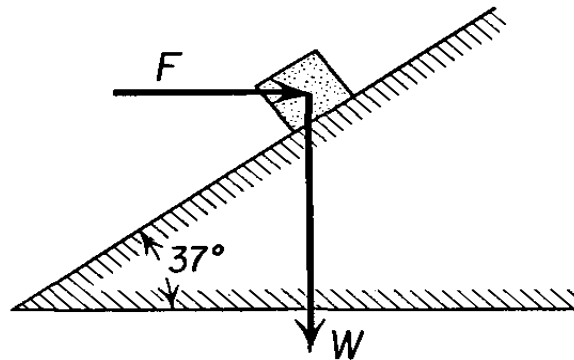
    (iii)Assume the surface is not smooth, and the coefficient of static friction is 0.8. What is the frictional force between the block and the plank? [2 marks]

(c) Referring to the figure below, suppose that the body is pulled along a level floor by a rope making an angle of 30^0 with the floor.
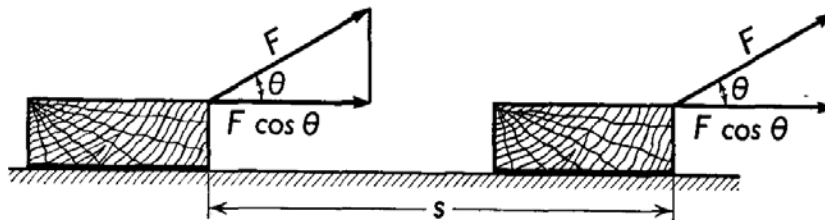
The body moves a distance of 15m. If the force F is 40N, and the power of the pulling machine is 26W, calculate:

    (i) The work done
    (ii) The time it will take for the body to move the distance
    (iii)The acceleration of the body
    (iv)The final velocity of the body
    (v) The kinetic energy of the body at the 15m mark   [2+2+2+2+2 marks]

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3 (a) Define the following terms

      (i) Torque
      (ii) Impact
      (iii)Elastic collision   [1+2+1 marks]

  (b) A Mercedes-Benz car with a mass of 2000kg is traveling at 60mph when it strikes a Volkswagen of mass 1000kg initially at rest. After the collision the two cars stick together. What is their velocity after the collision?   [2 marks]

  (c) A 0.02kg bullet if fired from a gun with a velocity of 500m/sec. If the gun weighs 5kg, what is the recoil velocity of the gun?   [2 marks]

  (d) Find the torque exerted by the wrench on the bolt in the diagram below;

$$F = 50 \text{ lb}$$

$$d = 0.5 \text{ ft}$$
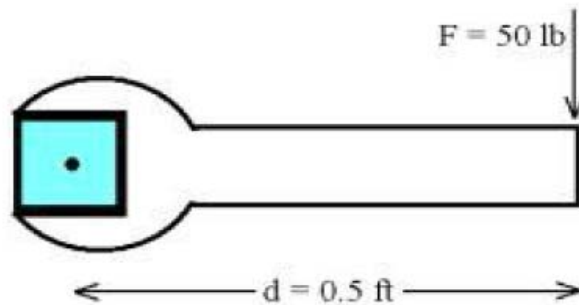
                                                        [2 marks]

  (e) A student with an arm of length 0.6m holds a suitcase weighing 25N in her hand. Calculate the torque exerted on her shoulder by the weight if she holds her arm:

      (i)   Stretched horizontally away from her body
      (ii)   Hanging it straight down
      (iii)   At an angle of 60^0 below horizontal   [2+2+2 marks]

  (f) A 16ft seesaw is pivoted in the centre. At what distance from the centre would a 200lb person sit to balance a 150lb person on the opposite end? (Sketch and label all the important quantities in this calculation)   [2+2 marks]

4. (a) Define the following terms:
    (i) Young's modulus   [2 marks]
    (ii) Poison ratio   [2 marks]

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(b) A 1mm diameter manganese bronze test specimen was subjected to an axial tensile load, and the following data were obtained.

Gauge length	10 mm
Final gauge length	12.25 mm
Load at proportional limit	18.50N
Elongation at proportional limit	0.016mm
Maximum load	55.00N
Load at rupture	42.00N
Diameter at rupture	0.845mm

Calculate the following the following:

(i) Proportional limit. [2 marks]
(ii) Modulus of elasticity. [2 marks]
(iii) Ultimate strength. [2 marks]
(iv) Percentage elongation. [1 mark]
(v) Percentage reduction in area. [1 mark]
(vi) Indicated rupture strength. [2 marks]
(vii) True rupture strength. [2 marks]

(c) A solid shaft 5m long is stressed at 80MPa when twisted through 4°, using G=83MPa.

(i) Compute the shaft diameter. [2 marks]
(ii) What power can be transmitted by the shaft at 20Hz? [2 marks]

5. (a) State and explain the following:

(i) Bernoulli principle. [3 marks]
(ii) Archimedes' principle. [3 marks]
(iii) Continuity equation. [3 marks]

(b) Oil at 20^oC ($\rho = 888kg/m^3$ and $\mu = 0.800kg/m.s$) is flowing steadily through an inlet and outlet where pressures are measured to be 745kPa and 97kPa, respectively. Determine the flow rate of oil through the pipe assuming the pipe is:

(i) Horizontal [3 marks]
(ii) Inclined at 50° upwards. [3 marks]
(iii) Inclined 15° down wards. [3 marks]
(iv) Verify that the flow through the pipe is laminar. [2 marks]

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6. (a) A compound belt and counter shaft drive is shown in the diagram below. The pulley

    diameters are: A 80cm, B 35cm, C 62cm and D 32cm.
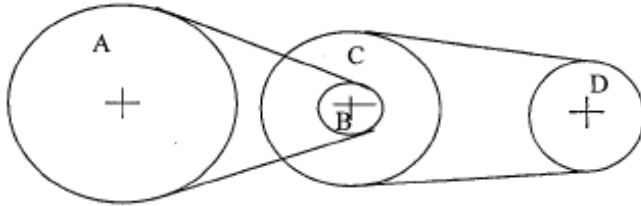
The power input to the pulley is 10kW at a speed of 100rev/min. If the belt drive is 85%
efficient calculate

(i)	The output power (kW) at D.	[4 marks]
(ii)	The speed of rotation of D.	[4 marks]
(iii)	The torque exerted at D.	[4 marks]

(b) A crate of mass 20kg is pulled up a rough incline with initial speed of 3.00m/s. The pulling
force is 200N parallel to the incline which makes an angle 40° with the horizontal. The
coefficient of kinetic friction is 0.400 and the crate is pulled 10.00m.

(i)	How much work is done by gravitational force on the crate?	[2 marks]
(ii)	Determine the increase in the internal energy due to friction.	[2 marks]
(iii)	How much work is done by the 200N force on the crate?	[2 marks]
(iv)	What is the speed of the crate after being pulled 10.00m?	[2 marks]

End of Examination!!!

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Trigonometry Table

Radian	Degree	Sine	Cosine	Tangent	Radian	Degree	Sine	Cosine	Tangent
0.000	0	0.000	1.000	0.000	0.803	46	0.719	0.695	1.036
0.017	1	0.017	1.000	0.017	0.820	47	0.731	0.682	1.072
0.035	2	0.035	0.999	0.035	0.838	48	0.743	0.669	1.111
0.052	3	0.052	0.999	0.052	0.855	49	0.755	0.656	1.150
0.070	4	0.070	0.998	0.070	0.873	50	0.766	0.643	1.192
0.087	5	0.087	0.996	0.087	0.890	51	0.777	0.629	1.235
0.105	6	0.105	0.995	0.105	0.908	52	0.788	0.616	1.280
0.122	7	0.122	0.993	0.123	0.925	53	0.799	0.602	1.327
0.140	8	0.139	0.990	0.141	0.942	54	0.809	0.588	1.376
0.157	9	0.156	0.988	0.158	0.960	55	0.819	0.574	1.428
0.175	10	0.174	0.985	0.176	0.977	56	0.829	0.559	1.483
0.192	11	0.191	0.982	0.194	0.995	57	0.839	0.545	1.540
0.209	12	0.208	0.978	0.213	1.012	58	0.848	0.530	1.600
0.227	13	0.225	0.974	0.231	1.030	59	0.857	0.515	1.664
0.244	14	0.242	0.970	0.249	1.047	60	0.866	0.500	1.732
0.262	15	0.259	0.966	0.268	1.065	61	0.875	0.485	1.804
0.279	16	0.276	0.961	0.287	1.082	62	0.883	0.469	1.881
0.297	17	0.292	0.956	0.306	1.100	63	0.891	0.454	1.963
0.314	18	0.309	0.951	0.325	1.117	64	0.899	0.438	2.050
0.332	19	0.326	0.946	0.344	1.134	65	0.906	0.423	2.145
0.349	20	0.342	0.940	0.364	1.152	66	0.914	0.407	2.246
0.367	21	0.358	0.934	0.384	1.169	67	0.921	0.391	2.356
0.384	22	0.375	0.927	0.404	1.187	68	0.927	0.375	2.475
0.401	23	0.391	0.921	0.424	1.204	69	0.934	0.358	2.605
0.419	24	0.407	0.914	0.445	1.222	70	0.940	0.342	2.747
0.436	25	0.423	0.906	0.466	1.239	71	0.946	0.326	2.904
0.454	26	0.438	0.899	0.488	1.257	72	0.951	0.309	3.078
0.471	27	0.454	0.891	0.510	1.274	73	0.956	0.292	3.271
0.489	28	0.469	0.883	0.532	1.292	74	0.961	0.276	3.487
0.506	29	0.485	0.875	0.554	1.309	75	0.966	0.259	3.732
0.524	30	0.500	0.866	0.577	1.326	76	0.970	0.242	4.011
0.541	31	0.515	0.857	0.601	1.344	77	0.974	0.225	4.331
0.559	32	0.530	0.848	0.625	1.361	78	0.978	0.208	4.705
0.576	33	0.545	0.839	0.649	1.379	79	0.982	0.191	5.145
0.593	34	0.559	0.829	0.675	1.396	80	0.985	0.174	5.671
0.611	35	0.574	0.819	0.700	1.414	81	0.988	0.156	6.314
0.628	36	0.588	0.809	0.727	1.431	82	0.990	0.139	7.115
0.646	37	0.602	0.799	0.754	1.449	83	0.993	0.122	8.144
0.663	38	0.616	0.788	0.781	1.466	84	0.995	0.105	9.514
0.681	39	0.629	0.777	0.810	1.484	85	0.996	0.087	11.430
0.698	40	0.643	0.766	0.839	1.501	86	0.998	0.070	14.301
0.716	41	0.656	0.755	0.869	1.518	87	0.999	0.052	19.081
0.733	42	0.669	0.743	0.900	1.536	88	0.999	0.035	28.636
0.750	43	0.682	0.731	0.933	1.553	89	1.000	0.017	57.290
0.768	44	0.695	0.719	0.966	1.571	90	1.000	0.000	∞
0.785	45	0.707	0.707	1.000					