NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF CIVIL AND WATER ENGINEERING
BACHELOR OF ENGINEERING (HONOURS) DEGREE
PART I EXAMINATION - APRIL 2014
TCW 1201: ENGINEERING MECHANICS – KINEMATICS AND DYNAMICS

INSTRUCTIONS
Answer any FOUR questions. Each question carries 25 marks.

Time: 3 Hours
Total Marks: 100

QUESTION 1

a) Explain the difference between instantaneous and average velocity and acceleration. [6]

b) Derive the following equations from first principles, stating the initial and final conditions of motion.

i. $v = v_o + at$

ii. $x = x_o + v_o t + \frac{1}{2}at^2$

iii. $v^2 = v_o^2 + 2a(x-x_o)$ [9]

c) A particle moves along a straight line such that its acceleration is $a = (4t^2 - 2)$ m/s^2, where t is in seconds. When $t = 0$, the particle is located 2 m to the left of the origin, and when $t = 2$ s, it is 20 m to the left of the origin. Determine the position of the particle when $t = 4$ s. [10]

QUESTION 2

The position of a particle is defined by $\mathbf{r} = \{t^3\mathbf{i} + 3t^2\mathbf{j} + 8t\,\mathbf{k}\}$ m, where t is in seconds. For the time, $t = 2$s, determine the magnitude of the:

i. Velocity,
ii. acceleration and the;
iii. radius of curvature of the path. [25]

QUESTION 3

If a force F = 200N is applied to the 30-kg cart shown in Figure 3.1, show that the 20-kg block *A* will slide on the cart. Also determine the time for block *A* to move on the cart 1.5 m. The coefficients of static and kinetic friction between the block and the cart are $\mu_s = 0.3$ and $\mu_k = 0.25$. Both the cart and the block start from rest. [25]

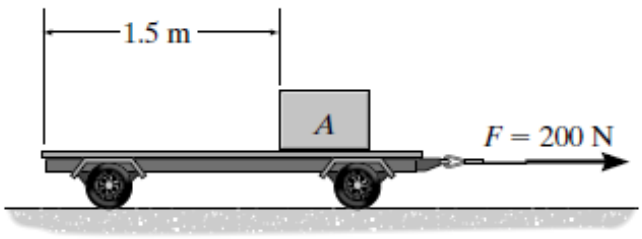

Figure 3.1

QUESTION 4

a) Figure 4.1 shows a 0.5-kg ball of negligible size which is fired up a smooth vertical circular track using a spring plunger. The plunger keeps the spring compressed 0.08 m when $s = 0$. Determine how far s it must be pulled back and released so that the ball will begin to leave the track when $\theta = 135°$. [15]

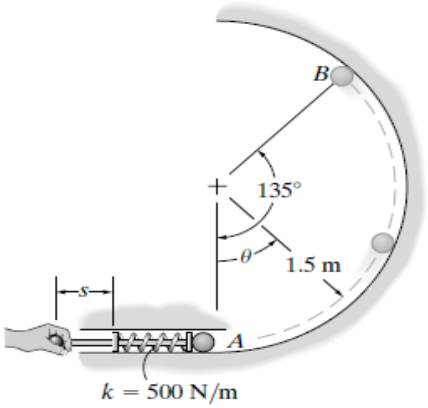

Figure 4.1

b) The crate shown in Figure 4.2 with a mass of 100 kg, is subjected to the action of the two forces. If it is originally at rest, determine the distance it slides in order to attain a speed of 6 m/s. The coefficient of kinetic friction between the crate and the surface is $\mu_k = 0.2$. [10]

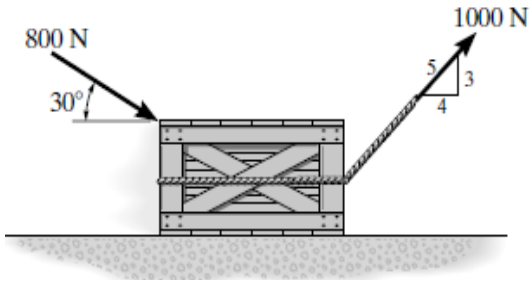

Figure 4.2

QUESTION 5

a) State the work-energy principle and show from first principles that $U_{1\text{-}2} = T_1 - T_2$. [10]

b) The 40-kg package shown in Figure 5.1 is thrown with a speed of 4 m/s onto the cart having a mass of 20 kg. If it slides on the smooth surface and strikes the spring, determine the velocity of the cart at the instant the package fully compresses the spring. What is the maximum compression of the spring? Neglect rolling resistance of the cart. [15]

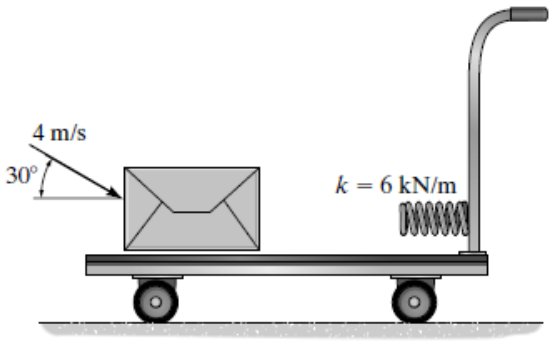

Figure 5.1