BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE EDUCATION

Diploma in Science Education Part 2.1

DM004/MT004: Mechanics Duration 3 hours

Semester Examinations

INSTRUCTIONS

Answer all questions in Section A and any **two** questions from Section B

Section A: (40 marks)

A1 (a) A particle with a mass of $2kg$ has position vector given by $\vec{r} = 3t^2\,\boldsymbol{i} - 2t\boldsymbol{j} - 3t\boldsymbol{k}$, where $\vec{r}$ is in metres and t is in seconds. For $t = 2s$, determine the magnitude of the force acting on the particle. **[5]**

(b). A particle of mass $5kg$ slides down a smooth plane inclined at $30°$ to the horizontal. Find the acceleration of the particle and show that the reaction between the particle and the plane is $R = \frac{5g\sqrt{3}}{2} N$. **[5]**

A2. (a) A car travelling at $30ms^{-1}$ is uniformly retarded to $10ms^{-1}$ in a distance of $60m$. Find the time taken . Find also the further distance it will travel in coming to rest if the retardation remains the same. **[7]**

(b) A car of mass $1500kg$ accelerates from $10ms^{-1}$ to $20ms^{-1}$ in $3s$. Find the tractive force assuming that it is constant. **[3]**

A3. (a) Find in the form $ai + bj$, a force of magnitude $8\sqrt{2}N$ acting along the line $3i - j + t(i - j)$. **[4]**

(b). Find in the form $xi + yj$:

(i) a force of $50N$ parallel to the vector 24i-7j. **[3]**

(ii) a force of $13N$ acting along the line of action from $A(1, -3)$ to $B(13, 2)$. **[3]**

A4. (a) Four forces are represented by the vectors: $3i - j$, $i + 7j$, $5j$, and $i + j$, determine the magnitude and direction of their resultant. **[5]**

(b) Find in the form $ai + bj$, a force of magnitude $8\sqrt{2}N$ acting along the line $3i - j + t(i - j)$. **[5]**

Section B [60 marks]

Answer **two** questions from this section being careful to number them **B5** to **B7.**

B5. (a). A particle starts moving from rest and moves in a straight line. Its acceleration $a\ ms^{-2}$ is given by $a = 3$ for $0 \leq t \leq 2$ and $a = -3$ for $2 < t \leq 6$ where t is in seconds.

(i). Find the velocities of the particle when $t = 2$ and when $t = 6$. **[4]**

(ii). Hence, sketch the (t,v) graph and find the total distance travelled by the particle in the interval **[4]**

(b) A particle of mass $0.5kg$ moves so that its position vector after t seconds is given by $r = (3t^2 - 2t^3)i - 2tj$. Determine the:

(i) velocity,

(ii) acceleration,

(iii) linear momentum of the particle when $t = 2s$. **[2, 3, 3]**

(c). (i) A particle is moving in a straight line with constant acceleration of $-4ms^{-2}$. If the initial velocity of the particle is $10ms^{-1}$, find its displacement after $2s$. **[5]**

(ii) The force acting in a straight line on a particle of mass m is of magnitude $km/(v + 1)$ where k is a constant and v is the speed of the particle when it has travelled a distance x. Find the distance moved when its speed increases from 0 to u. **[9]**

B6. (a) A ball is projected at an angle of $30°$ above the horizontal with a velocity of $36ms^{-1}$ from a point which is $1.5m$ above the ground. Calculate the magnitude of the velocity with which the ball hits the ground. **[7]**

(b) A particle moves in the $x - y$ plane and at time t is at the point $(3t^2 + 2, t - t^2)$. Prove that the particle has constant acceleration and find it. **[6]**

(c). A body of mass $5.2kg$ is held in equilibrium on a rough plane, by a force, $\vec{F}$ acting up the line of greatest slope. The plane is inclined at an angle θ to the horizontal where $\cos\theta = \frac{4}{5}$. When $\vec{F} = 19.2N$ the body is about to slide down the plane. Show that the coefficient of friction between the body and the plane $\mu = \frac{15}{52}$. [Use $= 10ms^{-2}$] **[8]**

(d) (i) A particle with an initial velocity of $v_o m/s$ starts moving in a straight line with constant acceleration a. Show that the displacement of the particle, s, after some time, t, is given by;

$s = v_o t + \frac{1}{2}at^2$. **[5]**

(iii) A force of $8N$ and a force ***P*** have a resultant of magnitude of $17N$. Determine ***P*** if the angle between the two forces is $60°$. **[5]**

B7. (a) A particle is projected from a point O on a horizontal plane with speed $40ms^{-1}$ at an angle θ to the horizontal, where $tan\theta = \frac{4}{3}$. Find;

(i) the time taken for the particle to return to the plane, **[5]**

(ii) the range of the particle, **[5]**

(iii) the speed after $2s$. **[5]**

(b) $PQRS$ is a square. Determine the resultant of the following forces: $5N$ acting along PQ, $3\sqrt{2}N$ along PR, $3N$ along PS. **[10]**

(c) A particle starting from rest moves with constant angular acceleration of $\frac{\pi}{4}\ rads^{-2}$. Find the angle it turns through in the third second of its motion. **[5]**

END OF PAPER