Mid-Semester Test

Time allowed : 1 hour

Instructions

Answer all **4** questions. Each question carries **25 marks**.

This question paper consists of **2** pages. You can use the A4 handwritten formula sheet compiled by you.

You are reminded that cheating during test is a serious offence.

All working in support of your answer must be shown. Answers must be to appropriate significant figures. Take g = 9.80 m/s^2.

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1. a) In dimensional analysis, what is meant by a homogenous equation?

   b) In the equation below, the SI units of x and x_0 are metres, t and t_0 are seconds, v_0 is m/s and a is m/s^2. Show whether this equation is homogenous or not.

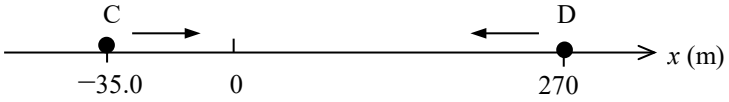
   $$x = x_0 + v_0(t - t_0) + \frac{1}{2}a(t - t_0)^2$$

   c) The force on a current carrying conductor is given by $\boldsymbol{F} = c\,(\boldsymbol{L} \times \boldsymbol{B})$, where c = 2.0 amperes. Determine the force $\boldsymbol{F}$ on a conductor whose length vector is $\boldsymbol{L}$ = 1.0 **i** + 2.0 **j** and the conductor is in a magnetic field $\boldsymbol{B}$ = 0.10 **k**. The SI units of $\boldsymbol{L}$ and $\boldsymbol{B}$ are metre and tesla respectively.

   (25 marks)

2. In the figure below, particles C and D move towards each other along the x-axis. At time t = 0, C is at x = −35.0 m and accelerates uniformly from rest at 2.00 m/s^2 while D is at x = 270 m and moving at constant speed 20.0 m/s.

   a) When do the particles meet?
   b) Where do the particles meet?
   c) What is the speed of C when it meets D?
   d) Sketch the position-time graphs of C and D using the same set of x-t axes.



(25 marks)

3. The position vector of a particle of mass 4.0 kg moving on the *x*-*y* plane is $\boldsymbol{r}(t) = 2t\,\mathbf{i} + t^2\,\mathbf{j}$, with $\boldsymbol{r}$ in metres and t in seconds. Calculate in component form the particle's

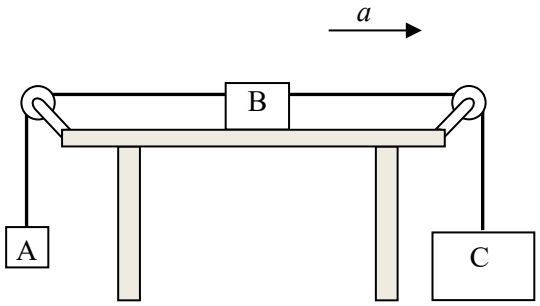
   a) average velocity from $t = 0$ to $t = 1.0$ s.
   b) instantaneous velocity at $t = 1.0$ s.
   c) instantaneous acceleration at $t = 1.0$ s.
   d) net force acting on the particle at $t = 1.0$ s.

(25 marks)

4. a) Three forces act on a particle of mass 3.0 kg such that it is at rest. Two of the forces are $\boldsymbol{F}_1 = 2.0\,\mathbf{i} - 7.0\,\mathbf{j} + 4.0\,\mathbf{k}$ N and $\boldsymbol{F}_2 = 4.0\,\mathbf{i} + 1.0\,\mathbf{k}$ N while the third force $\boldsymbol{F}_3$ is unknown.

      i) Write the relationship between $\boldsymbol{F}_1$, $\boldsymbol{F}_2$ and $\boldsymbol{F}_3$.
      ii) Find $\boldsymbol{F}_3$.

   b) The diagram below shows three blocks A, B and C attached by chords that loop over frictionless pulleys. Block B lies on a frictionless table. The masses of A, B and C are m_1, m_2 and m_3 respectively and that $m_3 > m_2 > m_1$. The tension in the chord connecting A and B is T_1 while the tension in the chord connecting B and C is T_2. When the blocks are released, they accelerate with a as shown. Find a and T_2 in terms of m_1, m_2 and m_3 and g, the acceleration due to gravity.



(25 marks)

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