BINDURA UNIVERSITY OF SCIENCE EDUCATION

PHYSICS AND MATHEMATICS DEPARTMENT

PH101: MECHANICS AND OSCILLATIONS

-- DEC 2019

DURATION: THREE HOURS

Answer **ALL** parts of Section A and any **THREE** questions from Section B. Section A carries 40 marks and Section B carries 60 marks.

SECTION A

1. a. Use dimensional analysis to show that the expression $v = v_0 + at$ is dimensionally correct, where v and v_0 represent velocities, a is acceleration, and t is a time interval. [3]

b. A small airplane leaves an airport on an overcast day and is later sighted 215 km away, in a direction making an angle of 22° east of due north. How far east and north is the airplane from the airport when sighted? [7]

c. During a hard sneeze, your eyes might shut for 0.50 s. If you are driving a car at 90 km/h during such a sneeze, how far does the car move during that time? [5]

d. A billiard ball of mass m = 170 g has velocity components $v_x = v_y$ = 4m/s, see Figure 1.1. The ball bounces back from a table's edge with the same speed and angle after being in contact with the edge for 0.2 s. Assume that friction and rotational motion are negligible.

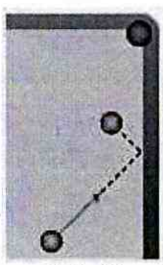


Figure 1.1: Question 1. d.

i. What is the change in the horizontal and vertical components of the ball's momentum? [6]

ii. What is the average force exerted on the ball by the wall? [3]

e. A block of mass m is pushed up a rough inclined plane of angle θ by a constant force $\vec{F}$ parallel to the incline, as shown in Figure 1.2. The displacement of the block up the incline is $\vec{d}$. $m = 2$ kg, $\mu_k = 0.5$, $\theta = 30°$, $\vec{F}$ = 20 N and $\vec{d}$ = 5 m. Find the work done by the force $\vec{F}$. [7]

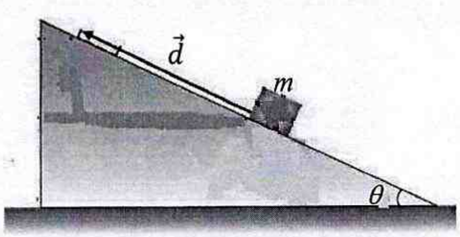
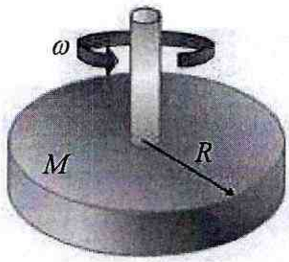


Figure 1.2: Question 1. e.

f. A disk of mass $M = 8$ kg and radius $R = 0.5$ m accelerates about its massless axle from rest to an angular speed $\omega = 8.5$ rad/s in a time $\Delta t = 2$ s, see Figure 1.3.



Find:

i. the angular momentum of the disk [5]

ii. the required constant torque used for this acceleration. [4]

SECTION B

2. a. A mass m hangs from a massless string of length l (see Figure 2.1) and swings back and forth in the plane of the paper. The acceleration due to gravity is g. What can we say about the frequency ω of oscillations? [10]

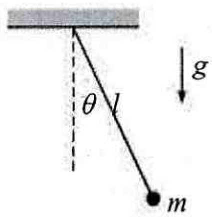


Figure 2.1: Question 2. a.

b. An engine produces 57 horsepower. 1 horsepower=550 foot pound-force/second

Quantity	System 1: British	System 2: SI	Ratio: British/SI
Mass	slug	kilogram	14.6
Length	foot	metre	0.3048
Time	second	second	1.0

i. What is the corresponding value in kilowatts? [8]

ii. What is the conversion factor? [2]

3. a. $\vec{A} = (4.2\text{ m})\vec{\imath} - (1.5\text{ m})\vec{\jmath}$ $\quad \vec{B} = (-1.6\text{ m})\vec{\imath} + (2.9\text{ m})\vec{\jmath}$ $\quad \vec{C} = (-3.7\text{ m})\vec{\jmath}$

i. What is the vector sum $\vec{R}$ of these three vectors? [5]

ii. What is the magnitude of $\vec{R}$? [3]

iii. What is the angle measured from the $+x$ direction, (θ)? [3]

b. Verify explicitly that $\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$ using $\vec{A} = 8\vec{\imath} + 3\vec{\jmath}$ and $\vec{B} = -5\vec{\imath} - 7\vec{\jmath}$. [9]

4. a. The position of a particle moving along the x-axis varies with time t according to the relation $x = t^3 - 12t + 20$, where x is given in metres and t in seconds.

b. i. Find the velocity and the acceleration of the particle as a function of time. [6]

c. ii. Is there ever a time when $v = 0$? [4]

d. iii. Describe the particle's motion for $t \geq 0$. [10]

5. a. A block of mass $m = 21$ kg hangs from three cords as shown in part of Figure. 5.1. Taking $\sin\theta = 4/5$, $\cos\theta = 3/5$, $\sin\varphi = 5/13$, and $\cos\varphi = 12/13$, find the tensions in the three cords. [15]

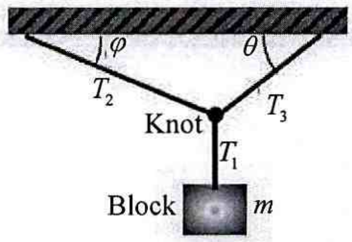


Figure 5.1: Question 5. a.

b. iv. A particle moves over a path such that the components of its position with respect to an origin of coordinates are given as a function of time by: [5]

$$x = -t^2 + 12\,t + 5$$

$$y = -2\,t^2 + 16\,t + 10$$

where t is in seconds and x and y are in metres. Find the particle's position vector $\vec{\ }$ as a function of time and find its magnitude at $t = 6$ s.

6. A particle oscillates with a simple harmonic motion along the x axis. Its displacement from the origin varies with time according to the equation:

$$x = (2\text{ m})\cos(0.5\pi t + \pi/3)$$

where t is in seconds and the argument of the cosine is in radians. Find:

a. the amplitude, frequency, and period of the motion. [4]

b. the velocity and acceleration of the particle at any time. [6]

c. both the maximum speed and acceleration of the particle. [4]

d. the displacement of the particle between t = 0 and t = 2 s. [6]

END OF EXAM