UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

PHYS 223.3 Midterm Examination

Instructor: Yansun Yao

Feb 15th, 2018 Time: 7:00 PM ~ 9:00 PM

ANSWER ALL FOUR QUESTIONS.

FULL MARK IS 100.

MARKS PER EACH QUESITON ARE INDICATED.

1. One-Dimensional Time Dependent Force

A block of mass m is initially at rest on a frictionless surface. At time $t = 0$, an external force is applied to the block,

$$F(t) = F_0 t e^{-\lambda t} .$$

Here F_0 and λ are time-independent constants.

(a) Find the speed of the block as a function of time, $v(t)$. (**10 marks**)

(b) Find the position of the block as a function of time, $x(t)$. (**10 marks**)

2. One-Dimensional Velocity Dependent Force

The motor of a speed boat is shut off when it has attained a speed of v_0. Now the boat is slowed down by a retarding force due to water resistance,

$$F_r(v) = -F_0 e^{kv} .$$

Here F_0 and k are time-independent constants.

(a) How long will it take for the boat to stop? (**12 marks**)
(b) How much distance will the boat travel before it stops? (**12 marks**)

3. An undamped harmonic oscillator of mass m, natural frequency ω_0, is initially at rest on an air track (considered as a frictionless surface). The oscillator is subject at $t_0 = 0$ to a blow so that it starts from $x_0 = 0$ with initial velocity v_0 and oscillates freely until $t_1 = \frac{3\pi}{2\omega_0}$. From this time on, a driven force $F_d(t) = F_0 \cos\left(\frac{\omega_0}{2} t\right)$ is applied to the oscillator.

(a) Find the position $x(t_1)$ and velocity $v(t_1)$ of the oscillator at t_1. (**16 marks**)

(b) Find the position $x(t_2)$ and velocity $v(t_2)$ of the oscillator at $t_2 = \frac{5\pi}{2\omega_0}$. (**16 marks**)

(c) After t_2, air pressure in the air track is reduced so a frictional force $F_f = -b\dot{x}$ is added to the surface. Once the oscillation reaches the steady state, its amplitude has the maximum possible value for this specific set of oscillator and driving force. Find the value of b. (**6 marks**)

4. Vectors

Vector $\mathbf{A} = a\hat{\mathbf{i}} + 5a\hat{\mathbf{j}} + 2\hat{\mathbf{k}}$ is perpendicular to another vector $\mathbf{B} = 3\hat{\mathbf{i}} - a\hat{\mathbf{j}} + 6a\hat{\mathbf{k}}$.

(a) Find all possible values of *a*. (**6 marks**)

(b) For each *a*, find the **area** of the parallelogram determined by **A** and **B**. (**12 marks**)

******************** END OF EXAM ********************