NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 210 – Mechanics & Heat Spring 2022

Quiz #3

INSTRUCTIONS:

(1) No graphic calculators are allowed for this quiz.
(2) Do all your work in the examination blue booklet
(3) You may find the following formulas useful:

(a) $v_t = \omega r$, $a_t = \alpha r$

(b) $W = Fx\cos\theta$, $\Delta U = -W$

(c) $K_E = \frac{1}{2}mv^2$, $U_g = mgh$

(d) Hooke's Law: $F = -kx$, $U_s = \frac{1}{2}kx^2$

(e) $W_{Total} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

(f) $\vec{\boldsymbol{p}} = m\vec{\boldsymbol{v}}$

(g) $R_{CM} = \frac{\sum_{i=1}^{N} m_i r_i}{M_{Total}} = \frac{m_1 r_1 + m_2 r_2 + \cdots + m_N r_N}{m_1 + m_2 + \cdots + m_N}$

(h) $I = \sum m_i r_i^2$

(i) $K_E = \frac{1}{2}I_z\omega^2 = \frac{1}{2}I_{CM}\omega^2 + \frac{1}{2}Mv_{CM}^2$

(j) $L = I\omega$

(k) Conservation of angular momentum: $\bar{\boldsymbol{L}}_{Total}^{initial} = \bar{\boldsymbol{L}}_{Total}^{final}$

(l) $\rho = \frac{m}{V}$, $P = \frac{F}{A}$

(m) $P_{bottom} = P_{Top} + \rho g d$

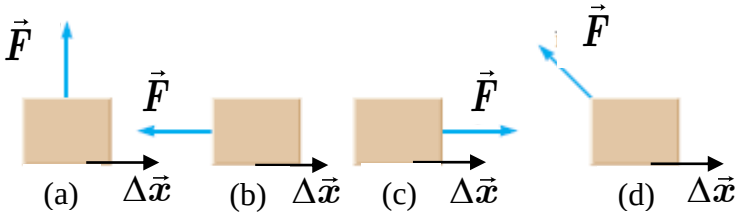
(n) $F_{buoyant} = \rho g V$

(o) Density of water = 1000 kg/m^3

(p) Conversion factor: 2π radians=1 rev=360° (rev=revolutions)

Show all your work in the solution of each problem.
Writing down a number with no work shown gets no credit.
Put each problem on a separate page in the blue booklet.

Problem 1 (25 points) (2 points each unless specified)



1.1 In Figures (a)-(d) above, a block moves to the right in the positive $x-$direction through the displacement $\Delta\vec{x}$ while under the influence of a force with the same magnitude $\vec{F}$. Which of the following is the correct order of the amount of work done by the force $\vec{F}$, from most positive to most negative?

(a) d, c, a, b (b) c, a, b, d
(c) c, a, d, b (d) a, c, d, b

1.2 Three identical balls are thrown from the top of a building, all with the same initial speed. The first ball is thrown horizontally, the second at some angle above the horizontal, and the third at some angle below the horizontal (as shown the right). Neglecting air resistance, rank the speeds of the balls as they reach the ground, from fastest to slowest:

(a) 1, 2, 3 (b) 2, 1, 3
(c) 3, 1, 2 (d) All balls strike the ground at the same time.

1.3 Elastic potential energy depends on the spring constant and the distance the spring is stretched or compressed. By what factor does the elastic potential energy change if the spring's stretch is (a) doubled or (b) tripled?

1.4 Two masses m_1 and m_2, with $m_1 < m_2$, have equal kinetic energy. How do the magnitudes of their momenta compare?

(a) Not enough information is given
(b) $p_1 < p_2$ (c) $p_1 = p_2$ (d) $p_1 > p_2$

1.5 A boy standing at one end of a floating raft that is stationary relative to the shore walks to the opposite end of the raft, away from the shore. As a consequence, the raft

(a) remains stationary (b) moves away from the shore
(c) moves toward the shore (d) rotates about its center

1.6 A bowling ball onboard a space station is floating at rest relative to the station and an astronaut nudges a small Ping-Pong ball (having much less mass than the bowling ball) toward it at speed v, initiating a perfectly elastic head-on collision. Which answer is closest to the Ping-Pong ball's speed after the collision?

(a) 0 (b) $v/2$ (c) v (d) $2v$ (e) $3v$

1.7 Two spheres, one hollow and one solid, are rotating with the same angular speed around an axis through their centers. Both spheres have the same mass and radius. Which sphere, if either, has the higher rotational kinetic energy?

(a) The hollow sphere (b) The solid sphere
(c) They both have the same kinetic energy

1.8 If global warming continues, it's likely that some ice from the polar ice caps of the Earth will melt and the water will be distributed closer to the equator. If this occurs, would the length of the day (one rotation)

(a) increase (b) decrease (c) remain the same

1.9 Blood pressure is normally measured with the cuff of the sphygmomanometer around the arm. Suppose the blood pressure is measured with the cuff around the calf of the leg of a standing person. Would the reading of the blood pressure be

(a) the same here as it is for the arm?
(b) greater than it is for the arm?
(c) less than it is for the arm?

1.10 The density of lead is greater than iron, and both metals are denser than water. Is the buoyant force on a solid lead object

(a) greater than (b) equal to (c) less than

the buoyant force acting on a solid iron object of the same dimensions?

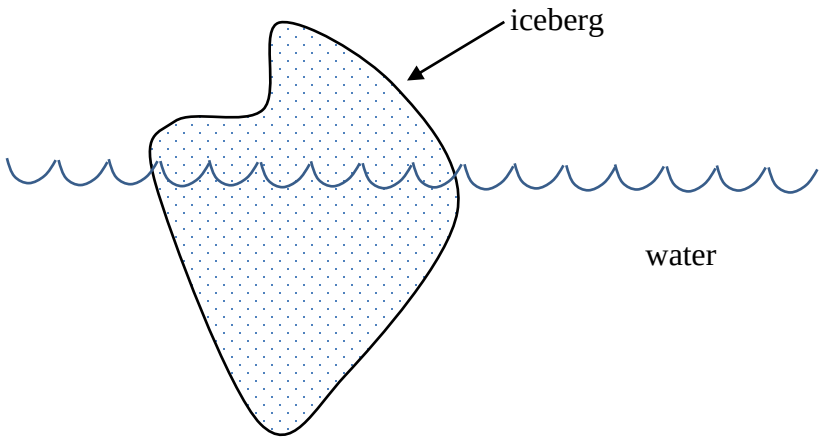
1.11 A solid glass ball weighs 1 N. One with twice the diameter weighs

(a) 1 N (b) 2 N (c) 3 N (d) 4 N (e) more than 4 N

1.12 Approximately how much air is in a column 1 cm2 in cross section that extends from sea level to the top of the atmosphere? **(3 points)**

(a) 1 gram
(b) 1 kg
(c) 10 kg
(d) 100 kg

Problem 2 (25 points)



A massive iceberg broke away from Antarctica. The density of the iceberg was measured to be 0.917 g/cm^3 and the density of the seawater was found to be 1.025 g/cm^3.

(a) Draw the free body diagram for the iceberg.

(b) Write down Newton's 2nd law for the forces in the vertical direction.

(c) Using your results from Part (b), find the percentage of the iceberg's volume that is below the surface? That is, find

$$V_{ice\ below\ surface} / V_{total\ iceberg}$$ (write answer as a percentage).

Problem 3 (25 points)

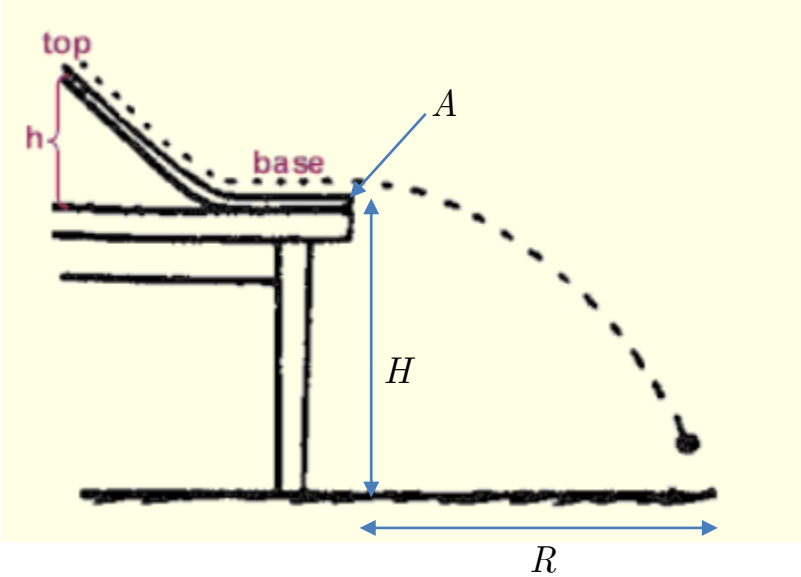
NIU Services wants to load a 12 kg crate into a truck by sliding it up a ramp 2.5 m long, inclined at 30º. An NIU physics student, giving no thought to friction, calculates that she can get the crate up the ramp by giving it an initial speed of 5.0 m/sec at the bottom. But friction is not negligible; the crate slides 1.6 m up the ramp, stops, and then slides back down.

(a) Assuming that the frictional force acting on the crate is constant, find the magnitude of the frictional force.

(b) How fast is the crate moving when it reaches the bottom of the ramp?

(c) What is the minimum initial speed she must give the crate for it to make it up the ramp?

Problem 4 (25 points)



A solid ball rolls down a ramp from a height h above the top of a table. The top of the table is a height H above the floor. The moment of inertia of the ball is $I = \frac{2}{5}mr^2$. Ignore all sources of friction.

(a) What is the speed v of the ball when it reaches point A? Express your answer in terms of h and g (the acceleration due to gravity).

(b) How far past the edge of the table, R, does the ball land? Express your answer in terms of h, H, and g.