Q1.
A proton moves along the x axis according to the equation $x(t) = 50.0\,t + 10.0\,t^2$, where x is in meters and t in seconds. Calculate the instantaneous acceleration of the proton at t = 3.00 s.

A) 20.0 m/s^2
B) 10.0 m/s^2
C) 30.0 m/s^2
D) 110 m/s^2
E) 130 m/s^2

Q2.
A rock is thrown vertically upward from ground level at time t = 0. At time t = 1.5 s it passes the top of a building of height H and 1.0 s later it reached its maximum height. What is the height H of the building?

A) 26 m
B) 42 m
C) 10 m
D) 15 m
E) 5.0 m

Q3.
Consider the following two vector $\vec{A} = 6.0\,\hat{i} + 1.0\,\hat{j}$ and $\vec{B} = -2.0\,\hat{i} + 3.0\,\hat{j}$. Find the magnitude of vector $\vec{C}$ such that $\vec{A}+\vec{B}+2\vec{C} = 12\,\hat{i} - 24\,\hat{j}$.

A) 14.6
B) 42.3
C) 20.4
D) 16.7
E) 30.0

Q4.
An airplane moves due east relative to the ground in a wind blowing 20 km/h toward the south. If the speed of the plane is 70 km/h relative to the wind, what is the speed of the airplane relative to the ground?

A) 67 km/h
B) 50 km/h
C) 90 km/h
D) 63 km/h
E) 20 km/h

Q5.
A ball is thrown horizontally from a height of 20 m and hits the ground with a speed that is three times its initial speed. What is the initial speed of the ball?

A) 7.0 m/s
B) 12 m/s
C) 9.8 m/s

D) 5.0 m/s
E) 20 m/s

Q6.
A car travels at a constant speed around a horizontal circular track. Which one of the following statements about this car is TRUE?

A) The velocity of the car is changing.
B) The velocity of the car is constant.
C) The acceleration vector of the car is constant.
D) The car has a velocity vector that points along the radius of the circular track.
E) The car has an acceleration vector that is tangent to the circular track at all times.

Q7.
A worker pulls a 30.0 kg box up a 30^o smooth inclined plane. He exerts on the box a force of magnitude 350 N parallel to the incline. Calculate the acceleration of the box.

A) 6.77 m/s^2
B) 3.34 m/s^2
C) 2.65 m/s^2
D) 8.91 m/s^2
E) 5.40 m/s^2

Q8.
Consider a ball of mass 0.04 kg attached to a string of negligible mass and length L moving in a horizontal circle of radius 0.20 m at constant speed as shown in Figure 1. Find the speed of the ball.

A) 1.1 m/s
B) 0.82 m/s
C) 2.3 m/s
D) 3.1 m/s
E) 0.18 m/s

Q9.
An 8.0 kg object is moving in the positive direction of an x-axis. When it passes through x = 0, a constant force directed along the x-axis begins to act on it. Figure 2 gives its kinetic energy versus position x as the object moves from x = 0 to x = 5.0 m. Find the acceleration of the object.

A) – 0.75 m/s^2
B) + 0.75 m/s^2
C) – 1.5 m/s^2
D) + 2.1 m/s^2
E) + 1.5 m/s^2

Q10.
Consider a massless spring of spring constant k = 20 N/m hanging from the ceiling in its relaxed state. A person applies a force of 10 N expanding the spring a vertical distance d. The potential energy stored in the spring is

A) 2.5 J
B) 3.4 J
C) 1.3 J
D) 5.3 J
E) 10 J

Q11.
Two blocks A and B (M_A = 50.0 kg and M_B = 100 kg) are connected by a string as shown in Figure 3. The pulley is frictionless and of negligible mass. Determine the change in kinetic energy of the two-block system as block B moves down a vertical distance of 20.0 m. Assume a smooth incline.

A) 13.7 kJ
B) 16.7 kJ
C) 5.83 kJ
D) 4.43 kJ
E) 9.91 kJ

Q12.
A 12.0 g bullet is fired into a 100 g wooden block initially at rest on a horizontal surface. The bullet stays inside the block after impact and the block-bullet system slides 7.50 m before coming to rest. If the coefficient of kinetic friction between the block and the surface is 0.650, what was the speed of the bullet immediately before impact?

A) 91.2 m/s
B) 45.4 m/s
C) 28.0 m/s
D) 62.5 m/s
E) 110 m/s

Q13.
A thin uniform rod of length L = 2.0 m is pivoted about a horizontal, frictionless pin through one end as shown in Figure 4. It is released from rest when it is in the vertical position. Determine the angular speed of the rod at the instant it passes through the horizontal position.

A) 3.8 rad/s
B) 2.1 rad/s
C) 4.3 rad/s
D) 1.5 rad/s
E) 5.3 rad/s

Q14.
The sun has a radius of 7.0 x 10^5 km and spins (rotates) around its central axis with a period of 25 days. What would be the new period if the sun was to shrink (decrease in size), under the action of central forces, to a radius of 1000 km? Assume the sun to be a solid sphere.

A) 4.4 seconds
B) 0.44 seconds
C) 4.4 minutes

D) 4.4 hours
E) 4.4 days

Q15.
Consider two objects A and B, rotating about fixed axes, with equal rotational kinetic energies. The rotational inertia of object A is twice that of object B. Find the ratio of the angular momentum of object A to that of object B (about their respective axes of rotations).

A) $\sqrt{2}$
B) 2
C) 1/2
D) 1
E) $\sqrt{3}$

Q16.
Three identical uniform rods are each acted on by the forces shown in Figure 5, all perpendicular to the rods and all equal in magnitude. Which of the rods could be in static equilibrium if an additional force is applied at the center of mass of the rod?

A) Only 3
B) Only 2
C) Only 1
D) Only 1 and 2
E) All three

Q17.
Consider a solid copper cube of edge length 85.5 cm. How much stress must be applied to the cube to reduce each edge length to 85.0 cm. The bulk modulus of copper is 1.4 x 10^{11} N/m^2.

A) 2.4×10^9 N/m^2.
B) 8.3×10^9 N/m^2.
C) 5.8×10^9 N/m^2.
D) 1.2×10^9 N/m^2.
E) 3.5×10^9 N/m^2.

Q18.
A uniform beam is 5.00 m long and has a mass of 53.0 kg. The beam is supported in a horizontal position by a hinge and a cable as shown in Figure 6. Find the x and y components of the force of the hinge on the beam.

A) -150 N, $+260$ N
B) $+260$ N, -150 N
C) -350 N, $+420$ N
D) $+350$ N, -420 N
E) -440 N, $+280$ N

Q19.

An astronaut weighs 140 N on the moon's surface. He is in a circular orbit of radius $2R_m$ around the moon, where $R_m = 1.74 \times 10^3$ km is the radius of the moon. Find the gravitational force of the moon on the astronaut on this orbit?

A) 35.0 N towards the moon.
B) 35.0 N away from the moon.
C) 20.0 N towards the moon.
D) 20.0 N away from the moon.
E) 55.0 N towards the moon.

Q20.
A 1000 kg satellite is in a circular orbit of radius = $3R_e$ about the Earth. How much energy is required to transfer this satellite to an orbit of radius = $6R_e$?

A) 5.220×10^9 J
B) 3.260×10^9 J
C) 7.230×10^9 J
D) 9.800×10^9 J
E) 1.390×10^9 J

Q21.
A satellite of mass m moves around a planet (of mass M) in a circular orbit of radius R = 9.400×10^3 km with a period of 2.754×10^4 s. Find the mass M of the planet.

A) 6.500×10^{23} kg
B) 3.500×10^{23} kg
C) 2.400×10^{22} kg
D) 8.500×10^{24} kg
E) 9.800×10^{22} kg

Q22.
A rocket of mass m is launched from the surface of a planet of mass M = 5.93×10^{27} kg and radius R = 6.75×10^3 km. What minimum initial speed is required if the rocket is to rise to a height of 4R above the surface of the planet? (Neglect the effects of the atmosphere).

A) 3.10×10^5 m/s
B) 4.30×10^4 m/s
C) 6.42×10^4 m/s
D) 1.32×10^5 m/s
E) 9.16×10^5 m/s

Q23.
Two particles A and B of masses $m_A = 5.2$ kg and $m_B = 2.4$ kg are placed on a horizontal frictionless surface a distance d = 4.0 m apart. How much work is required by an external agent to triple (three times) the separation between the particles?

A) 1.4×10^{-10} J
B) 2.1×10^{-10} J
C) 4.3×10^{-10} J
D) 0.75×10^{-10} J

E) 5.4×10^{-10} J

Q24.
A person floats in the ocean with 90% of his body below the water surface. The density of the ocean water is 1025 kg/m^3. What is the person's average density in kg/m^3?

A) 922.5
B) 1025
C) 1000
D) 900.0
E) 945.2

Q25.
A large tank, open to the atmosphere, is filled with water to a height of 16 m. A small hole is opened at a height of 6.0 m above the bottom of the tank. What is the speed (in m/s) of the water through the hole?

A) 14
B) 16
C) 60
D) 22
E) 10

Q26.
A balloon filled with helium gas that occupies a volume of 0.0500 m^3 is attached by a light rope to the ground. What is the tension in the rope? (Density of helium gas = 0.1786 kg/m^3, density of air = 1.293 kg/m^3)

A) 0.5460 N
B) 546.0 N
C) 5.460 N
D) 54.60 N
E) None of the others

Q27.
Oil is flowing through a horizontal tube that has two different cross-sectional areas as shown in Figure 7. At position A where the radius of the tube is 7.00 cm, the mass flow rate of the oil is 0.025 kg/s. What is the mass flow rate at position B where the radius of the tube is 3.50 cm?

A) 0.025 kg/s
B) 0.013 kg/s
C) 0.038 kg/s
D) 0.050 kg/s
E) 0.100 kg/s

Q28.
A particle oscillates according to the displacement equation x = (0.20 m) cos (2πt), where x is in meters and t in seconds. What is the speed and acceleration of the particle as it passes its equilibrium position x = 0.

A) 1.3 m/s, 0
B) 2.2 m/s, 7.9 m/s^2
C) 3.2 m/s, 0
D) 0.89 m/s, 7.9 m/s^2
E) 4.1 m/s, 2.1 m/s^2

Q29.
Consider a uniform rod of length L suspended from one end and oscillating with period T. The slope of the graph of T^2 versus L is 3 (s^2/m). What is the acceleration due to gravity in m/s^2 from the above information?

A) 8.8
B) 7.8
C) 9.8
D) 10.8
E) None of the others

Q30.
A simple harmonic oscillator consists of a 0.80 kg block attached to a spring (k = 200 N/m). The block oscillates on a frictionless horizontal surface about the equilibrium point x = 0 with a total mechanical energy of 4.0 J. What is the speed of the block at x = 0.15 m?

A) 2.1 m/s
B) 4.3 m/s
C) 0.80 m/s
D) 1.5 m/s
E) 0.15 m/s

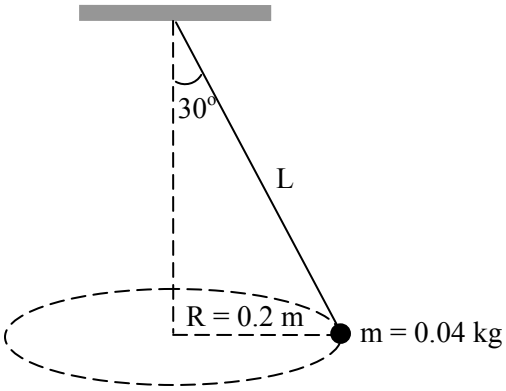

Figure 1

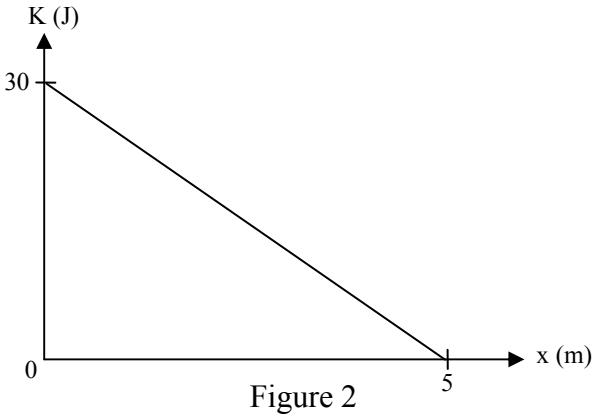

Figure 2

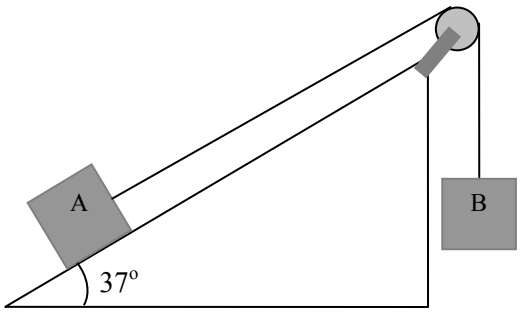

Figure 3

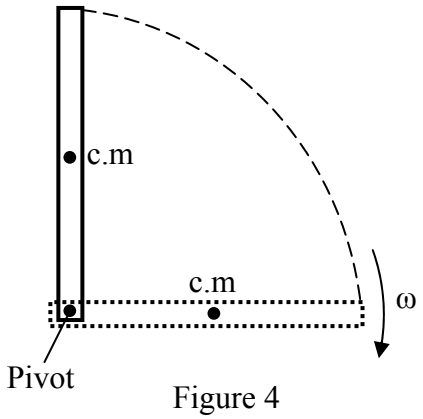

Figure 4

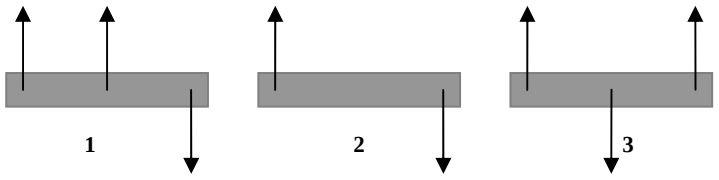

Figure 5

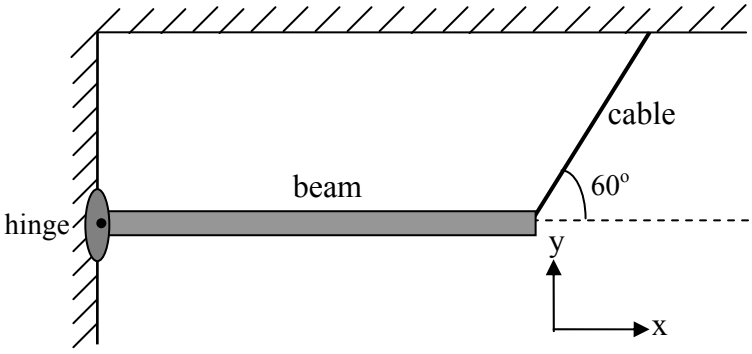

Figure 6

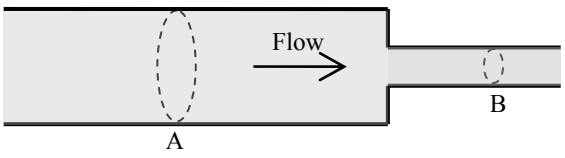

Figure 7