Q1.
Which of the following is the correct combination of dimensions for energy?

A) ML^2/T^2
B) LT^2/M
C) MLT
D) M^2L^3T
E) ML/T^2

Q2.
Two cars are initially 150 kilometers apart and traveling toward each other. One car is moving at 60.0 km/h and the other is moving at 40.0 km/h. In how many hours will they meet?

A) 1.50
B) 2.00
C) 1.75
D) 2.50
E) 1.25

Q3.
The angle in degrees between vector $\vec{A} = (-25.00\text{ m})\,\hat{i} + (45.0\text{ m})\,\hat{j}$ and the positive x axis is:

A) 119
B) 315
C) 61.0
D) 209
E) 241

Q4.
A stone is thrown horizontally from the top of a building. It then follows the path XYZ in air as shown in **Figure 1**. Rank the horizontal speed of the stone at points X, Y, and Z from highest to lowest (neglect air resistance).

A) All tie
B) Z, then Y, then X
C) X, then Y, then Z
D) X and Z tie, then Y
E) Y, then X, then Z

Q5.
Two horizontal forces perpendicular to each other act at the same time on a 5.0-kg box on a horizontal frictionless floor. One force is 6.0 N and the other is 8.0 N in magnitude. The magnitude of the acceleration of the box is:

A) 2.0 m/s^2
B) 0.50 m/s^2
C) 2.8 m/s^2
D) 10 m/s^2
E) 50 m/s^2

Q6.
A 40-N box rests on a rough horizontal floor. A 12-N horizontal force is then applied to it. If the coefficients of friction are $\mu_s = 0.50$ and $\mu_k = 0.40$, the magnitude of the frictional force on the box is:

A) 12 N
B) 8.0 N
C) 16 N
D) 20 N
E) 40 N

Q7.
A 0.50-kg object moves in a circular trajectory of radius 2.5 m on a horizontal frictionless table. An external constant force of 3.0 N, always tangent to the trajectory, causes the object to speed up as it goes around. The work done by this external force as the object makes one revolution is:

A) 47 J
B) 24 J
C) 59 J
D) 94 J
E) 12 J

Q8.
An ideal spring is hung vertically from the ceiling. When a 2.0-kg mass hangs at rest from it the spring extends 6.0 cm from its relaxed length. A downward external force is now applied to the mass to extend the spring an additional 10 cm. Find the work done by the spring force while the spring extension changes from 6.0 cm to 16 cm.

A) – 3.6 J
B) – 2.4 J
C) + 2.4 J
D) + 5.4 J
E) + 4.6 J

Q9.
A 0.50 kg ball is dropped vertically from rest from a height of 3.0 m and bounces back to a maximum height of 2.0 m. The magnitude of the energy dissipated in the collision with the floor is:

A) 4.9 J
B) 2.3 J
C) 9.9 J
D) 5.8 J
E) 6.2 J

Q10.
The mass of the moon is about 0.0123 times the mass of Earth and the distance from the center of the moon to the center of Earth is about 60 times the radius of Earth. How far is the center of mass of Earth-moon system from the center of Earth? Take Earth's radius to be 6400 km.

A) 4666 km
B) 3342 km
C) 6400 km
D) 1230 km
E) 7380 km

Q11.
A billiard ball (A) moving with a velocity of $(2.2\ \text{m/s})\,\hat{i}$ strikes an identical stationary ball (B). After the collision ball A is found to be moving at a speed of 1.1 m/s in a direction making 60° angle above the positive x-axis. Ball B is moving at an angle of 30^{o} below the positive x-axis. Find the speed of ball B after collision.

A) 1.9 m/s
B) 1.2 m/s
C) 1.6 m/s
D) 2.1 m/s
E) 2.9 m/s

Q12.
A constant torque of 0.80 N·m applied to a pulley increases its angular speed, about its frictionless axel, from 45 rev/min to 180 rev/min in 3.0 s. Find the moment of inertia of the pulley.

A) 0.17 $\text{kg}\cdot\text{m}^2$
B) 0.05 kg.m^2
C) 0.56 kg.m^2
D) 5.9 kg.m^2
E) 0.33 kg.m^2

Q13.
The meter stick shown in **Figure 2** rotates about an axis through point P, 20 cm from one end. Five forces act on the stick. All forces are in the plane of the paper and have equal

magnitude. Rank these forces according to the magnitudes of the torques they produce about the pivot point P, least to greatest.

A) $\vec{F}_2$ and $\vec{F}_5$ tie, then $\vec{F}_4$, then $\vec{F}_1$ and $\vec{F}_3$ tie

B) $\vec{F}_2$, $\vec{F}_5$, $\vec{F}_1$ and $\vec{F}_3$ tie, then $\vec{F}_4$

C) $\vec{F}_1$, $\vec{F}_2$, $\vec{F}_3$, $\vec{F}_4$, $\vec{F}_5$

D) $\vec{F}_1$ and $\vec{F}_2$ tie, then $\vec{F}_3$, $\vec{F}_4$, $\vec{F}_5$

E) $\vec{F}_2$ and $\vec{F}_5$ tie, then $\vec{F}_4$, $\vec{F}_1$, $\vec{F}_3$

Q14.

A solid uniform sphere of mass M and radius R rolls on a horizontal surface with a speed V and then up an inclined plane without sliding to a height h where it momentarily stops as shown in **Figure 3**. Knowing that g is the acceleration due to gravity, the value of h is:

A) $\frac{7}{10g}V^2$

B) $\frac{3}{4g}V^2$

C) $\frac{1}{g}V^2\sin\theta$

D) $\frac{4g}{5}V^2\cos\theta$

E) $\frac{V^2}{g}$

Q15.

A uniform steel rod of length 1.00 m and mass 2.00 kg rests horizontally on two supports at its ends. A 4.00-kg block is placed on the rod at a distance 25.0 cm from one end. Find the forces of the two supports on the rod.

A) 39.2 N and 19.6 N
B) 29.4 N and 29.4 N
C) 58.8 N and 0 N
D) 40.2 N and 18.6 N
E) 48.8 N and 10.0 N

Q16.

A uniform ladder of weight 50.0 N rests on a rough horizontal floor and against a smooth vertical wall. The ladder is about to slip when it makes an angle $\theta = 60^0$ with the floor. Find the force exerted by the wall on the ladder at this angle θ.

A) 14.4 N

B) 43.3 N
C) 28.8 N
D) 86.6 N
E) 50.0 N

Q17.
A horizontal aluminum rod, 4.0 cm in diameter, extends 5.0 cm out of a wall. A 1000 kg object is hung vertically from the end of the rod. The shear modulus of aluminum is 3.0 x 10^{10} N/m^2. Neglecting the rod's mass, calculate the vertical deflection of the end of the rod.

A) 1.3 x 10^{-5} m
B) 0.3 x 10^{-5} m
C) 1.1 x 10^{-5} m
D) 0.6 x 10^{-5} m
E) 0.9 x 10^{-5} m

Q18.
In **Figure 4** the applied force of magnitude F = 19.6 N keeps the 6.00 kg block and the pulleys in equilibrium. The pulleys have negligible mass and friction. Find the tension T in the upper cable.

A) 78.4 N
B) 39.4 N
C) 18.6 N
D) 58.8 N
E) 49.0 N

Q19.
A small satellite is in an elliptical orbit around Earth as shown in **Figure 9**. L_1 and L_2 denote the magnitudes of its angular momentum and K_1 and K_2 denote its kinetic energy at positions 1 and 2, respectively. Which of the following statements is CORRECT?

A) $L_2 = L_1$ and $K_2 > K_1$
B) $L_2 > L_1$ and $K_2 > K_1$
C) $L_2 = L_1$ and $K_2 = K_1$
D) $L_2 < L_1$ and $K_2 = K_1$
E) $L_2 > L_1$ and $K_2 = K_1$

Q20.
A rocket is fired vertically from Earth's surface with an initial speed of 2.0 x 10^4 m/s. Neglecting air resistance, calculate its speed when it is very far from Earth.

A) 1.7 x 10^4 m/s
B) 1.2 x 10^4 m/s
C) 1.3 x 10^4 m/s

D) 2.4×10^4 m/s
E) zero

Q21.
Two moons orbit the same planet in circular orbits. Moon A has orbital radius R, and moon B has orbital radius 4R. Moon A takes 20 days to complete one orbit. How long does it take moon B to complete its orbit?

A) 160 days
B) 20 days
C) 80 days
D) 320 days
E) 100 days

Q22.
What would be the weight of a 100-kg man on Jupiter? The mass of Jupiter is equal to 318 times the mass of Earth and the radius is 11 times that of Earth.

A) 2.6×10^3 N
B) 0.98×10^3 N
C) 3.1×10^3 N
D) 1.0×10^3 N
E) 3.9×10^3 N

Q23.
The hydraulic jack shown in **Figure 5** is used to raise the mass M through a height of 5.0 mm by performing 500 J of work on the small piston. The diameter of the large piston is 10 cm while that of the small piston is 2.0 cm. The mass M is:

A) 1.0×10^4 kg
B) 1.0×10^5 kg
C) 1.0×10^6 kg
D) 1.0×10^3 kg
E) 1.0×10^2 kg

Q24.
A solid cube of wood 30.0 cm on each edge is totally submerged in water when pushed downward with a vertical force of 54.0 N holding it in equilibrium. The density of wood is approximately:

A) 800 kg/m^3
B) 400 kg/m^3
C) 600 kg/m^3
D) 500 kg/m^3
E) 300 kg/m^3

Q25.
A tube of radius R is connected horizontally in series with another tube of radius R/2 as shown in **Figure 6**. Water enters the wider tube with speed v_1 = 1 m/s. The water pressures in the tubes are P_1 and P_2, respectively such that P_1+P_2 = 10000 Pa. Choose the correct values for P_1 and P_2 (in Pa).

A) P_1= 8750 and P_2= 1250
B) P_1= 8000 and P_2= 2000
C) P_1= 6500 and P_2= 3500
D) P_1= 5250 and P_2= 4750
E) P_1= 7525 and P_2= 2475

Q26.
Figure 7 shows a snapshot of a fluid within a U-shaped tube that has both sides open at the top. Is this fluid in static equilibrium at this instant?

A) No, because the fluid level in both sides should be at the same height.
B) No, because the fluid level in side A should be lower than that in side B.
C) No, because the cross-sectional area of side A is less than that of side B.
D) Yes, the fluid is in static equilibrium.
E) The answer may be yes or no, depending on the density of the fluid.

Q27.
A 0.200-kg block attached to a spring whose spring constant is 500 N/m executes simple harmonic motion. If its maximum speed is 5.00 m/s, the amplitude of its oscillation is:

A) 0.100 m
B) 0.002 m
C) 0.200 m
D) 1.00 m
E) 20.0 m

Q28.
A 0.10 kg block oscillates back and forth along a straight line on a frictionless horizontal surface. Its displacement as a function of time is given by $x(t) = 0.10\cos(10t + \pi/2)$ where x is in meters and t in seconds. The kinetic energy of the block at t = 2.0 sec is:

A) 8.3 mJ
B) 5.4 mJ
C) 10 mJ
D) 1.5 mJ
E) 3.0 mJ

Q29.

The acceleration a(t) of a particle undergoing simple harmonic motion is graphed as a function of time in **Figure 8**. Which of the labeled points corresponds to the particle at $-\mathbf{x_m}$, where x_m is the amplitude of the motion?

A) 3
B) 1
C) 2
D) 4
E) 5

Q30.
A horizontal block-spring system is set in a simple harmonic motion. The block has a kinetic energy of 8 J and an elastic potential energy of 4 J when the displacement of the block is 3.0 cm from the equilibrium point. What is the amplitude of this simple harmonic motion?

A) 5.2 cm
B) 6.0 cm
C) 3.5 cm
D) 4.0 cm
E) 3.0 cm

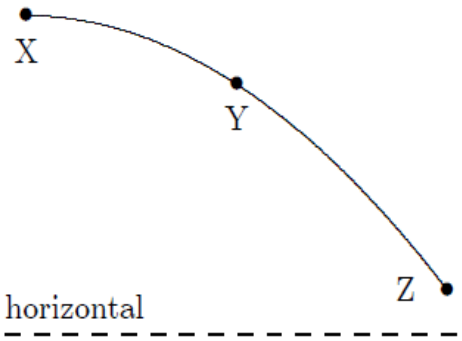


Figure 1

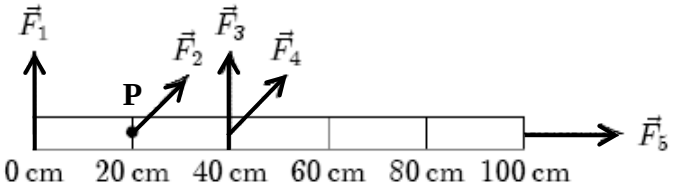
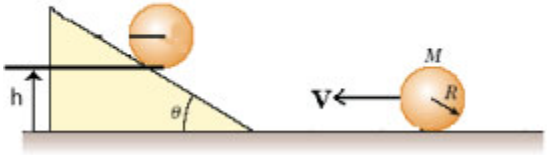


Figure 2



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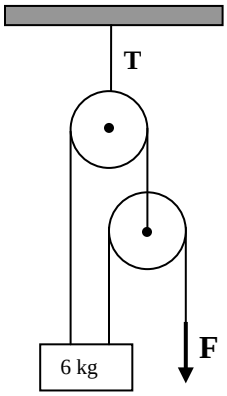

Figure 4

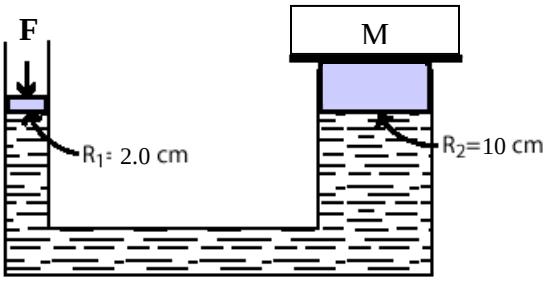

Figure 5

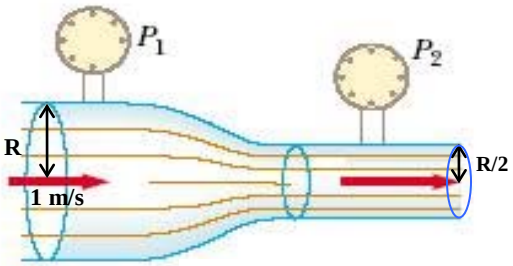

Figure 6

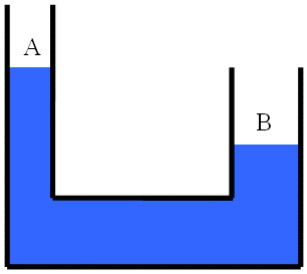

Figure 7

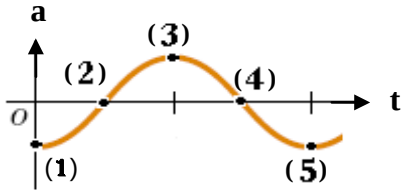

Figure 8

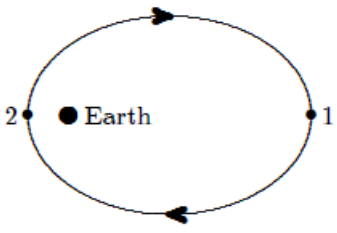

Figure 9