Q1.

The angular momentum $\ell$ of a system is given by the equation $\ell = k_1 x^2 + k_2 v$, where x is distance and v is speed. The dimensions of $k_1$ and $k_2$, respectively, are

A) $MT^{-1}$ and $ML$
B) $MT$ and $M^{-1}L^{-1}$
C) $M^{-1}T^{-1}$ and $M^{-1}T^{-1}$
D) $M^2T^{-2}$ and $M^{-2}T^2$
E) $ML$ and $ML$

---

Q2.

You are driving your car at a speed of 60 km/h when you suddenly see a child crossing the street a distance of 100 m away. At that instant you apply the brakes. What is the minimum deceleration required in order for you to stop your car just before hitting the child?

A) 18,000 km/h$^2$
B) 18 km/h$^2$
C) 300 km/h$^2$
D) 15 km/h$^2$
E) 15,000 km/h$^2$

Q3.

A stone is thrown from the ground into the air with an initial velocity of $(5\hat{i}+12\hat{j})$ m/s. Find its speed at the maximum height.

A) 5 m/s
B) 12 m/s
C) 13 m/s
D) 17 m/s
E) 0

---

Q4.

A block of mass 10 kg is pushed by a horizontal constant force $\vec{F}$ across a 30° frictionless incline as shown in Figure 1. Find the magnitude of the force $\vec{F}$ if the block is moving at constant velocity.

A) 56.6 N
B) 24.5 N
C) 15.2 N
D) 67.3 N
E) 0

---

Q5.

A car goes over the top of a hill the cross section of which can be approximated to a circle of radius R = 255 m as shown in Figure 2. What is the maximum speed the car can have at the top of the hill without leaving the road?

A) 50 m/s
B) 25 m/s
C) 100 m/s
D) 10 m/s
E) 75 m/s

---

Q6.

A box of mass 1.0 kg is pushed through a displacement $\vec{d} = 2.0\,\hat{i} - 4.0\,\hat{j}$ by a force $\vec{F} = 10\,\hat{i} - 5.0\,\hat{j}$, where $\vec{d}$ is in meters and $\vec{F}$ is in Newtons. How much work is done by the force during this displacement?

A) 40 J
B) 30 J
C) 10 J
D) 20 J
E) 0

---

Q7.

A box of mass 2.0 kg is held at the top of a $30^{\circ}$ incline. The incline is 4.0 m in length and the coefficient of kinetic friction between the box and the incline is 0.2. What is the speed of the box at the bottom of the incline if it is released from rest?

A) 5.1 m/s
B) 7.5 m/s
C) 2.5 m/s
D) 1.2 m/s
E) 9.8 m/s

---

Q8.

A body of mass $m_1$ = 1.0 kg moving with a velocity $\vec{v}_1 = \hat{i} - 3.0\,\hat{j}$ collides with another body of mass $m_2$ = 2.0 kg having a velocity $\vec{v}_2 = 7\,\hat{i} - 6\,\hat{j}$, where both velocities are in m/s. If the collision is completely inelastic, the speed of the combined system after the collision is

A) 7.1 m/s
B) 2.5 m/s
C) 3.2 m/s
D) 9.5 m/s
E) 0

---

Q9.

A disk of rotational inertia of $5.0\ \text{kg}\cdot\text{m}^2$ rotates about a fixed axis with an angular acceleration of 3.0 rad/s$^2$. If it starts from rest, the work done by the net torque on the disk during the first 10 seconds is

A) 2250 J
B) 2580 J
C) 3500 J
D) 3680 J
E) 2500 J

---

Q10.
The position of a 3.0 kg particle relative to the origin is given by $\vec{r} = (2.0\,t^2\,\hat{i} + 3.0\,t\,\hat{j})$; where $\vec{r}$ is in meters and t is time in seconds. What is the angular momentum of the particle in $\text{kg}\cdot\text{m}^2/\text{s}$ about the origin at t = 2.0 s?

A) $-72\hat{k}$
B) $-72\hat{i}$
C) $-12\hat{j}$
D) $-12\hat{k}$
E) $-12\hat{i}$

---

Q11.
The earth moves around the sun in an elliptical orbit with the sun at one focal point. Kepler's second law states that the radius vector from the sun to the earth sweeps equal areas in equal times. Kepler's second law holds because

A) The angular momentum of the earth about the sun is conserved.
B) The linear momentum of the earth is conserved.
C) The total energy of the earth is conserved.
D) The kinetic energy of the earth is conserved.
E) The potential energy of the earth is conserved.

---

Q12.
A particle attached to one end of a string is forced to move in a circular path of radius 3.0 m on a horizontal frictionless surface. The string breaks when the kinetic energy of the particle is 45 J. What is the tension in the string just before it breaks?

A) 30 N
B) 15 N
C) 10 N
D) 25 N
E) 0

---

Q13.

In Figure 3, there are three particles, each having a mass m = 2.0 kg and acted upon by a force F of magnitude 10 N in the direction indicated in the figure. What is the magnitude of the acceleration of the center of mass of the system shown?

A) 3.2 m/s$^2$
B) 5.4 m/s$^2$
C) 2.1 m/s$^2$
D) 0.83 m/s$^2$
E) 6.2 m/s$^2$

---

Q14.
A force $\vec{F} = 10\,N$ is applied to block 1 as shown in Figure 4. The masses of blocks 1, 2, and 3 are 5 kg, 3 kg, and 2 kg, respectively. What is the magnitude of the force exerted by block 2 on block 1? Assume the surface is frictionless.

A) 5 N
B) 10 N
C) 2 N
D) 20 N

---

Q15.
Two masses $m_1$ = 2.5 kg and $m_2$ = 5.0 kg are hanging as shown in Figure 5. Find the tension T in the horizontal string between the two masses. Assume the strings are massless.

A) 42 N
B) 14 N
C) 25 N
D) 10 N
E) 0

---

Q16.
A 90-kg mountain climber is tied to one end of an elastic rope of unstretched length 15 m and diameter 9.6 mm. The climber falls and the rope is stretched by 3 cm. Find Young’s modulus of the rope.

A) 6.1 x $10^9$ N/m$^2$
B) 2.6 x $10^9$ N/m$^2$
C) 0.4 x $10^9$ N/m$^2$
D) 4.5 x $10^9$ N/m$^2$
E) 8.7 x $10^9$ N/m$^2$

---

Q17.
A uniform ladder of length L and mass M rests against a smooth, vertical wall. The coefficient of static friction between the ladder and the ground is 0.40. Find the angle θ (in degrees), between the ladder and the ground, at which the ladder is about to slide.

A) 51.3
B) 8.45
C) 45.0
D) 30.0
E) 60.0

---

Q18.
The escape velocity of a rocket from the surface of the earth is $v_1$. What is the escape velocity of the same rocket from the surface of a planet whose radius and acceleration due to gravity are each 5 times as those of the earth?

A) 5 $v_1$
B) $v_1$
C) 25 $v_1$
D) $v_1/5$
E) $v_1/25$

---

Q19.
Three point masses $m_2$ = 1.0 kg, $m_1 = m_3$ = 2.0 kg, are aligned on a straight line as shown in Figure 6. Take L = 15 cm and d = 5.0 cm. What is the work needed to move $m_2$ from its original position to a final position a distance d from $m_3$?

A) 0
B) 4 J
C) 6 J
D) 2 J
E) 12 J

---

Q20.
What is the net gravitational force, in Newtons, on mass $m_5$ = 500 kg located at the center of the square as shown in Figure 7. The masses on the corners are $m_1 = m_4$ = 200 kg, $m_2$ = 300 kg and $m_3$ = 100 kg.

A) $5.34 \times 10^{-5}$ towards $m_2$
B) $5.34 \times 10^{-5}$ towards $m_3$
C) $2.68 \times 10^{-5}$ upward
D) $2.68 \times 10^{-5}$ downward
E) 0

---

Q21.
Two satellites are revolving around the earth. The first satellite has a mass $m_1$ = 2M and potential energy $U_1$ = U, while the second one has a mass $m_2$ = 3M and potential energy $U_2$ = 3 U. The ratio of their orbital radii $R_1/R_2$ is

A) 2.0
B) 2.5
C) 1.5

D) 1.0
E) 5.0

---

Q22.
In 1957 the Russians put the first satellite in orbit. The Americans were able to measure the period and orbital speed of the satellite but could not determine its mass and, therefore, were not able to know the power of the Russian rocket that put the satellite in orbit. The power of the rocket is a measure of the military power of a country because powerful rockets can be used to carry massive bombs. The Americans were not able to determine the mass of the orbiting Russian satellite because:

A) The period of revolution of a satellite is independent of its mass.
B) The Americans did not have the technology to find the mass of the satellite.
C) The Russians put a device in the satellite that prevented others from finding its mass.
D) The Russian satellite was sending signals that interfered with the measurements.
E) The mass of the satellite was too small to be measured from far away.

---

Q23.
A uniform block of wood floats in water with two-thirds of its volume submerged. What is the density of the wood?

A) 0.67 $g/cm^3$
B) 0.75 $g/cm^3$
C) 1.25 $g/cm^3$
D) 0.97 $g/cm^3$
E) 1.5 $g/cm^3$

---

Q24.
On a standard day (atmospheric pressure), a pressure gauge instrument below the surface of the ocean (*Specific Gravity* = 1.025) reads an absolute pressure of $1.4 \times 10^6$ Pa. How deep underwater is this instrument?

A) 129 m
B) 133 m
C) 140 m
D) 15.7 m
E) 100 m

---

Q25.
A vertical cross section of a simple geological model of the earth that requires mountains to have roots is shown in Figure 10. At some horizontal level in the fluid mantle (called the *level of compensation*), the pressure has a constant value (the pressures at points A and B in the figure are equal). How deep must the root (d) of the mountain approximately be?

A) 13 km
B) 23 km

C) 33 km
D) 43 km
E) 53 km

---

Q26.
A Venturi meter is installed in a water main line, as shown in Figure 8. The pipe has a circular cross-section, with diameter $D_1$ in the first segment and $D_2$ in the second segment, with $D_2 < D_1$. The density of water is ρ. The volume flow rate of the water in the pipe is $R_v$ (measured in $m^3/s$). What is the difference in the water level Δh in the two tubes?

A) $\frac{8R_v^{\,2}}{\pi^2 g}\left(\frac{1}{D_2^4}-\frac{1}{D_1^4}\right)$
B) $\frac{8R_v^{\,2}}{\pi^2 g}\left(\frac{1}{D_2^2}-\frac{1}{D_1^2}\right)$
C) $\frac{8g}{\pi^2 R_v^{\,2}}\left(\frac{1}{D_2^4}-\frac{1}{D_1^4}\right)$
D) $\frac{8g}{\pi^2 R_v^{\,2}}\left(D_1^4-D_2^4\right)$
E) $\frac{R_v^{\,2}}{g}\left(\frac{1}{D_2^4}-\frac{1}{D_1^4}\right)$

---

Q27.
Consider a fresh-water ice cube floating in a glass of fresh water. When the ice cube melts, which of the following statements is TRUE?

A) The water level remains the same because the ice cube displaces a mass of water equal to its own mass.
B) The water level rises because ice is less dense than water.
C) The water level falls because ice is less dense than water.
D) The water level rises because the ice cube displaces a mass of water equal to its own mass.
E) The water level falls because the ice cube displaces a mass of water equal to its own mass.

---

Q28.
Two identical springs of spring constant k = 500 N/m are attached to a block of mass m = 0.1 kg as shown in Figure 9. The block is pulled to one side a small distance and let to oscillate. What is the angular frequency of oscillations on the frictionless floor?

A) 100 rad/s
B) 70.7 rad/s
C) 50 rad/s

D) 0
E) 5000 rad/s

---

Q29.
A block of mass m = 0.1 kg oscillates on the end of a spring with a spring constant k = 400 N/m in simple harmonic motion with a period T. The position of the block is given by $x(t) = (10.0\,\text{cm})\cos(\omega t)$. What is the work done on the block by the spring as it moves it from t = 0 to t = T/8. Ignore friction.

A) 1.0 J
B) 5.0 J
C) 0.1 J
D) 400.0 J
E) 40. 0 J

---

Q30.
A physical pendulum consists of a uniform solid disk of radius R = 2.0 cm supported in a vertical plane by a pivot located at the edge of the disk. The disk is displaced by a small angle θ and released from rest. What is the period of the resulting simple harmonic motion?

A) 0.35 *s*
B) 0.50 *s*
C) 0.21 *s*
D) 0.15 *s*
E) 2.1 *s*

---

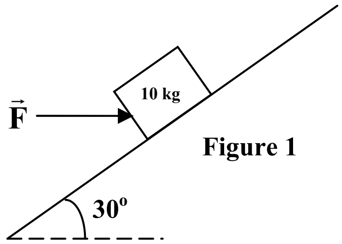


Figure 1

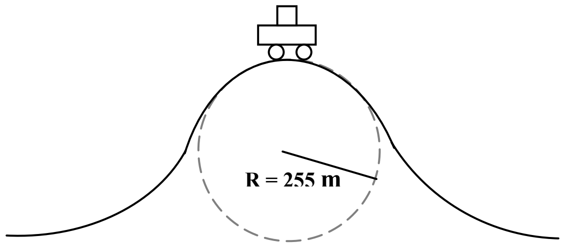


Figure 2

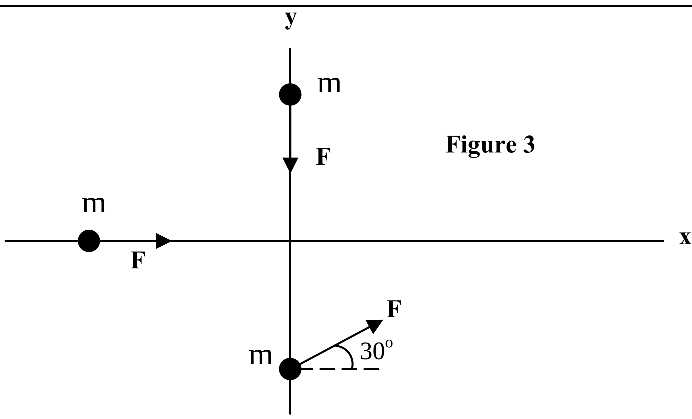


Figure 3

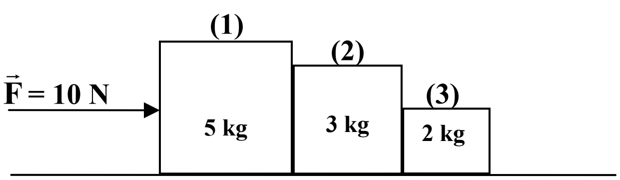


Figure 4

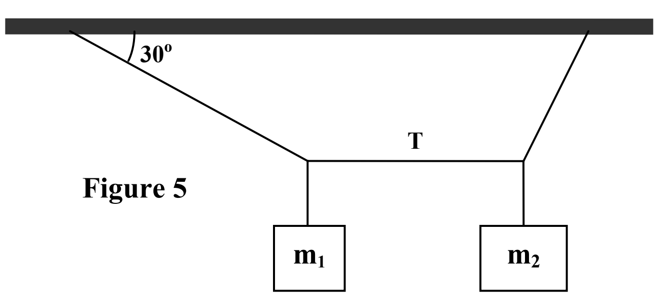


Figure 5

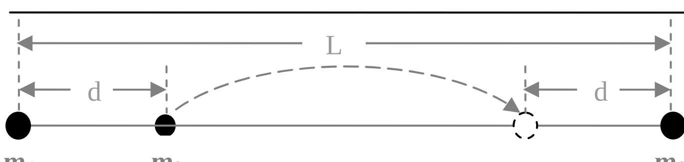


Figure 6

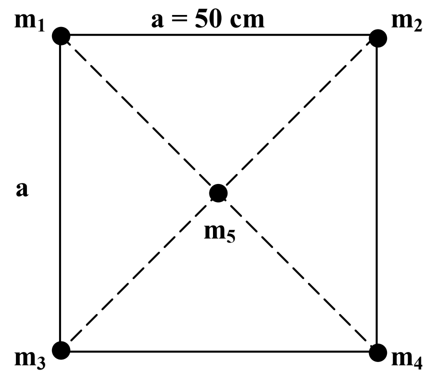


Figure 7

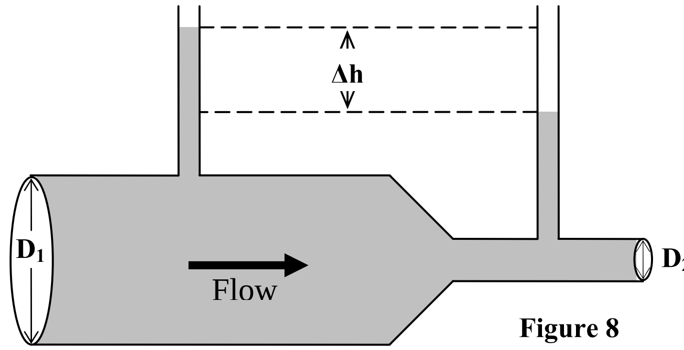


Figure 8

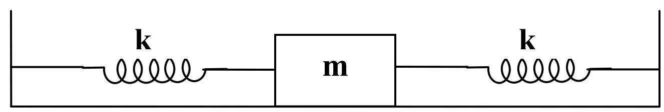


Figure 9

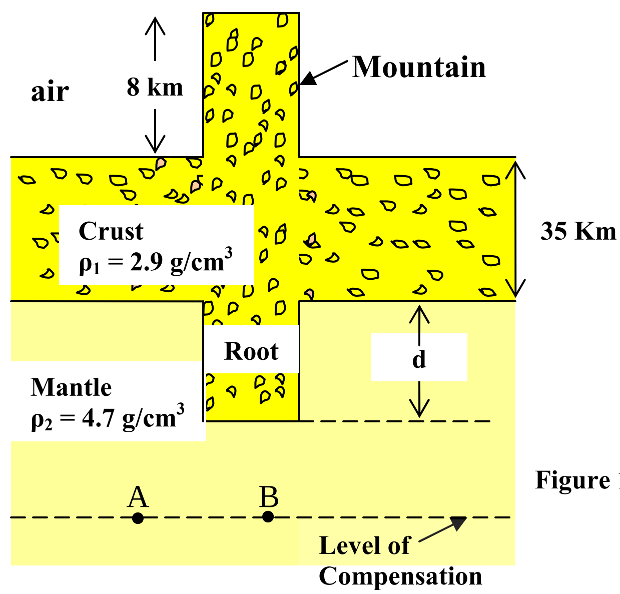


Figure 10

PHYS101-Final Exam-081