solutions
1. This is to identify the exam version you have – IMPORTANT
Mark the A

2. This is to identify the exam version you have – IMPORTANT
Mark the B

3. Mass $m$ exerts a gravitational force $F$ on mass $M$ when they are a distance $R$ apart. When the two masses are a different distance apart, the force $m$ exerts on $M$ is $9F$. This different distance is:

   (a) $R$
   (b) $3R$
   (c) $9R$
   (d) $R/3$
   (e) $R/9$

4. What is the apparent weight of a cube of iron of volume 0.2 m$^3$ when it is submerged in water? The density of iron is 7800 kg/m$^3$, and that of water is 1000 kg/m$^3$.

   (a) 1960 N
   (b) 13,300 N
   (c) 15,300 N
   (d) 1560 N
   (e) 78,400 N

5. A mass of 0.2 kg on a spring oscillates with a frequency of 20 Hz. With a different mass on the same spring, the frequency is 10 Hz. That different mass is:

   (a) 0.2 kg
   (b) 0.4 kg
   (c) $0.8$ kg
   (d) 0.1 kg
   (e) 0.05 kg
6. The only force acting on a 2.0-kg object moving along the x axis is shown. If the velocity \( v_i \) is \(-2.0 \text{ m/s} \) at \( t = 0 \), what is the velocity at \( t = 4.0 \text{ s} \)?

\[ p_f = p_i + \Delta p = p_i + \int F \, dc \]

\[ \Delta x = \left( -\frac{2}{3} \right) \frac{kr^3}{m} \]

\[ v_f = \frac{-6k_i}{2k_f} = -2 \frac{v_i}{5} \]

a. \(-2.0 \text{ m/s}\)
b. \(-4.0 \text{ m/s}\)
c. \(-3.0 \text{ m/s}\)
d. \(+1.0 \text{ m/s}\)
e. \(+5.0 \text{ m/s}\)

7. A 3.0-kg mass is released from rest at point A of a circular frictionless track of radius 0.40 m as shown in the figure. The mass slides down the track and collides with a 1.4-kg mass that is initially at rest on a horizontal frictionless surface. If the masses stick together, what is their speed after the collision?

\[ v = \sqrt{2 \frac{m v^2}{2 \frac{m v^2}{2}}} \]

\[ v = \frac{m}{m + m} \sqrt{2 \frac{m v^2}{2}} \]

\[ v_f = \frac{m}{m + m} \sqrt{2 \frac{m v^2}{2}} \]

a. 2.1 m/s
b. 1.7 m/s
c. 1.9 m/s
d. 1.5 m/s
e. 2.3 m/s
8. The rigid object shown is rotated about an axis perpendicular to the paper and through point P. The total kinetic energy of the object as it rotates is equal to 1.4 J.
If \( M = 1.3 \) kg and \( L = 0.50 \) m, what is the angular velocity of the object? Neglect the mass of the connecting rods and treat the masses as particles.

\[
I = 2M \cdot L^2 + 2 \cdot 2M \cdot (\frac{L}{2})^2 = 3ML^2
\]

\[
\omega = \sqrt{\frac{2 \cdot K_{rot}}{I}}
\]

- a. 1.3 rad/s
- b. 1.5 rad/s
- c. 1.7 rad/s
- d. 1.2 rad/s
- e. 2.1 rad/s

9. The graphs below show angular velocity as a function of time. In which one is the magnitude of the angular acceleration constantly decreasing?

![Graphs](image)

- a. (a)
- b. (b)
- c. (c)
- d. (d)
- e. (e)

10. A solid sphere, spherical shell, solid cylinder and a cylindrical shell all have the same mass \( m \) and radius \( R \). If they are all released from rest at the same elevation and roll without slipping, which reaches the bottom of an inclined plane first?

- a. solid sphere
- b. spherical shell
- c. solid cylinder
- d. cylindrical shell
- e. all take the same time

Useful:
- solid sphere: \( I = \frac{2}{5} MR^2 \)
- spherical shell: \( I = \frac{2}{3} MR^2 \)
- solid cylinder: \( I = \frac{1}{2} MR^2 \)
- cylindrical shell: \( I = MR^2 \)
### Question 11
Five identical cylinders are each acted on by forces of equal magnitude. Which force exerts the biggest torque?

![Diagram of five cylinders](image)

(a) ![Image](image) (b) ![Image](image) (c) ![Image](image) (d) ![Image](image) (e) ![Image](image)

### Question 12
A satellite is in a circular orbit about the Earth at an altitude at which air resistance is negligible. Which of the following statements is true?

a. There is only one force acting on the satellite.
b. There are two forces acting on the satellite, and their resultant is zero.
c. There are two forces acting on the satellite, and their resultant is not zero.
d. There are three forces acting on the satellite.
e. None of the preceding statements are correct.

### Question 13
Planet Roton has a mass of \(4.0 \times 10^{23}\) kg and a radius of \(2.0 \times 10^6\) m. With what speed should a space probe be launched from the surface of Roton so as to achieve a maximum distance of \(3.0 \times 10^8\) m from the center of Roton?

a. 4.2 km/s  
b. 3.9 km/s  
c. 3.0 km/s  
d. 3.4 km/s  
e. 6.0 km/s

\[
\frac{1}{2} m v_i^2 - G \frac{m_R m_P}{R} = - G \frac{m_R m_P}{R_f} \\
V_i = \sqrt{2 G m_R \left( - \frac{1}{R_f} + \frac{1}{R_R} \right)}
\]
14. Two circus clowns (each having a mass of 50 kg) swing on two flying trapezes (negligible mass, length 25 m) shown in the figure. At the peak of the swing, one grabs the other, and the two swing back to one platform. The time for the forward and return motion is

\[ T = \frac{1}{2} \sqrt{\frac{L}{g}} \]

\[ f = \frac{1}{2\pi} \sqrt{\frac{g}{L}} \]

a. 10 s
b. 50 s
c. 15 s
d. 20 s
e. 25 s

15. A graph of position versus time for an object oscillating at the free end of a horizontal spring is shown below. A point or points at which the object has positive velocity and zero acceleration is(are)

a. B
b. C
c. D
d. B or D
e. A or E