
Solutions to Mock Exam #1 Multiple-Choice Questions

Dr. Timothy Leung

1. (D) For any projectile, there are two angles that have the same range, and the sum of the angle is 90° . If one of the angle is 60° , then the other angle is 30° .
2. (B) The maximum range occurs at 45° , so the horizontal distance will **increase**.
3. (C) The driver of the car is rounding a circular path, so the centripetal force on the driver is provided by the difference between gravity (which contributes to F_c), and normal force (which contributes against F_c , and is what we are solving here), i.e.:

$$F_c = F_g - F_N$$

$$F_N = F_g - F_c = mg - \frac{mv^2}{r} = m \left(g - \frac{v^2}{r} \right) = 50 \left(10 - \frac{20^2}{50} \right) = 50(10 - 8) = \boxed{100 \text{ N}}$$

4. (A) The forces that X and Y exert on each other must be equal by the third law of motion, therefore

$$\boxed{F_{\text{up}} = F_{\text{down}}}$$

When Block Y is stationary, the acceleration is at its maximum, therefore the forces F_{up} must be higher than the weight of block Y , $m_Y g$:

$$\boxed{F_{\text{up}} > m_Y g}$$

5. (C) There is no external net force, so when the water is added to the cart, the **total momentum is conserved**. As the mass increases, it means that the **velocity must decrease**.
6. (D)
7. (B) In a vacuum, both objects will have the same acceleration (due to gravity). If both are *released* (i.e. dropped with zero initial velocity), then both will have the same speed.
8. (B) The “block-Earth” system does not include the spring, and so energy is conserved from B to C. If this is a “spring-block-Earth” system, then the answer would be A.
9. (B) The reflected wave is in the same medium, and so it must have the same speed and amplitude as before (I and II are incorrect). It is reflected from a fixed end, and therefore the wave would be inverted (III).
10. (B) The area under both graphs are the same, and therefore the impulse is the same, which means that the change in momentum is the same.

11. (A) The definition of equilibrium is that an object is not subjected to any net external force.
12. (C) By the conservation of energy,

$$\begin{aligned}
 U_g &= K' + U'_g \\
 mgH &= \frac{1}{2}mv^2 + mgh' \\
 H &= \frac{v^2}{2g} + h' = \frac{3.0^2}{2 \cdot 9.8} + 0.4 = \boxed{0.86 \text{ m}}
 \end{aligned}$$

The calculation would have been 0.85 m if you used $g = 10 \text{ m/s}^2$.

13. (A) The path that the block travels is curved, so at the bottom, there will be a centripetal force. In order to generate this centripetal force, normal force F_n must be greater than gravity F_g .
14. (C) After the block leaves the track, it will travel as a projectile. The horizontal velocity is constant in a projectile, which we can calculate from when the block leaves the ramp. At the highest point of this projectile motion, it has the only horizontal component:

$$v_x = v \cos 30^\circ = 3.0 \cdot \cos 30^\circ = \boxed{2.6 \text{ m/s}}$$

15. (A) Satellite 1 is closer to Earth than Satellite 2, therefore $F_1 > F_2$, since gravitational force is inversely proportional to the square of the distance. We can obtain the orbital velocity by equating the centripetal force to gravitational force:

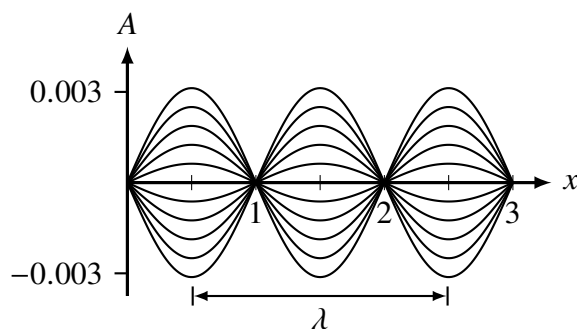
$$F_c = F_g \quad \rightarrow \quad \frac{mv^2}{r} = \frac{GMm}{r^2} \quad \rightarrow \quad v = \sqrt{\frac{GM}{r}}$$

Satellite 1 is closer to Earth than Satellite 2, therefore it also has a higher speed.

16. (D) Work is positive if force is in the same direction as motion, and negative when it's opposite. It does not matter if the speed is constant or not.
17. (B) This is a completely inelastic collision because the carts stick together. Using conservation of momentum:

$$mv_i = (M + m)v_f \quad \rightarrow \quad v_f = \underbrace{\left(\frac{m}{M + m} \right)}_{\text{slope}} v_i$$

18. (C) A standing wave would like this. The nodes are located at $x = 1, 2, 3$. The distance between nodes are half of the wavelength.



19. **(D)** At equilibrium, the gravitational and spring forces on the 3 kg mass must balance, i.e.:

$$mg = kx \rightarrow x = \left(\frac{g}{k}\right)m$$

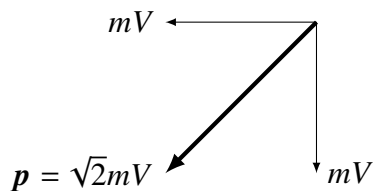
The stretching of the spring at equilibrium is proportional to the mass m . Replacing the 3 kg mass with a 4 kg mass will increase the equilibrium stretch to $12 \times \frac{4}{3} = 16$ cm which is also the magnitude of the “oscillation”, if it happens. However, position when direction of motion is reversed is twice the amplitude, i.e. 32 cm.

20. **(D)** As the wave moves, energy is dissipated by friction, therefore the amplitude decreases.
21. **(A)** The torque generated by the force is

$$\tau = FL \sin \theta$$

If the force is applied perpendicularly, that would mean a moment arm of $L \sin \theta$.

22. **(D)** The total momentum of the third piece must cancel the momentum of the other two masses, i.e.:

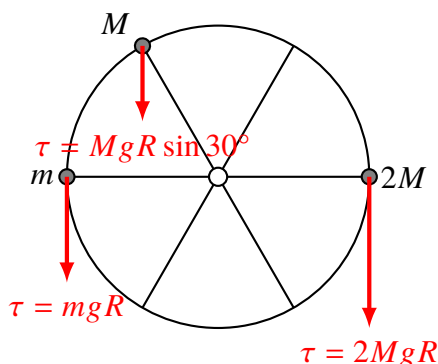


The mass of the third piece is $3m$, therefore the velocity must be

$$v = \frac{p}{m} = \frac{\sqrt{2}mV}{3m} = \frac{\sqrt{2}}{3}V \text{ [✓]}$$

23. **(C)** Bringing the disk up to a higher angular velocity in the same time interval means a higher angular acceleration, which requires a higher torque $\tau = I\alpha$.

24. (C) The axle is horizontal, which means that the wheel rotates vertically. The torques generated by the masses are drawn on the diagram:



If the wheel is in equilibrium, then the torques acting on it must sum to zero, i.e.

$$2MgR = mgR + \frac{1}{2}MgR \longrightarrow \boxed{m = \frac{3}{2}M}$$

25. (E) The angular momentum of an object is defined as:

$$L = rmv = 4 \cdot 2 \cdot 4.5 = \boxed{24 \text{ kg} \cdot \text{m/s}}$$

26. (D) The weight of the beam acts at the center of mass, and generates a torque of

$$\tau_g = mg \frac{L}{2} = 10 \cdot 9.8 \cdot \frac{2}{2} = 98 \text{ N} \cdot \text{m} \text{ [clockwise]}$$

while the applied force generates a torque of

$$\tau_F = FL \sin \theta = 200 \cdot 2 \sin 30^\circ = 200 \text{ N} \cdot \text{m} \text{ [counterclockwise]}$$

The net torque is $\boxed{\tau_{\text{net}} = 102 \text{ N} \cdot \text{m}}$ counterclockwise.

27. (C) The maximum velocity of a spring-mass system is given by $v_{\text{max}} = A\omega$. The angular frequency is based on mass and spring constant. However, we still need the amplitude, which can be found from the maximum acceleration, $a_{\text{max}} = A\omega^2$, or $A = a_{\text{max}}/\omega^2$.

28. (B) The functions for velocity and acceleration is out of phase by 90° .

29. (A) When Disk B is dropped onto Disk A, there is no external torque applied, therefore angular momentum remains the same. This means that the angular frequency ω is decreased by $\frac{1}{2}$, while the rotational moment (moment of inertia) increases by a factor of 2. The new kinetic energy is therefore

$$K' = \frac{1}{2}I'\omega'^2 = \frac{1}{2} \cdot 2I \cdot \left(\frac{\omega}{2}\right)^2 = \frac{1}{2}K$$

And the kinetic energy is decreased to $\frac{1}{2}$ of its original value.