



Université d'Ottawa • University of Ottawa

Faculté des sciences
Physique

Faculty of Science
Physics

PHY1121

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Final, OPEN-BOOK Examination: 3 hours

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- Three identical very dense masses of 5800 kg each are placed on an x axis. One mass is at -112 cm, one is at the origin, and one is at 385 cm. What is the magnitude of the gravitational force on the mass at the origin due to the other two masses? Take the gravitational constant G to be $6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$.
 - $2.10 \times 10^{-3} \text{ N}$
 - $1.97 \times 10^{-3} \text{ N}$
 - $1.78 \times 10^{-3} \text{ N}$
 - $1.64 \times 10^{-3} \text{ N}$
 - $1.23 \times 10^{-3} \text{ N}$
- Astronomers have observed a small, massive object at the center of our Milky Way galaxy. A ring of material orbits this massive object; the ring has a diameter of about 14.5 light years and an orbital speed of about 210 km/s. Take the distance of one light year to be $9.461 \times 10^{15} \text{ m}$. Determine the mass of the massive object at the center of the Milky Way galaxy in solar masses, where one solar mass is equal to the mass of the sun, which is $1.99 \times 10^{30} \text{ kg}$.
 - 2.14×10^7
 - 2.14×10^9
 - 2.07×10^7
 - 2.07×10^9
 - 2.28×10^7
- A certain spherical asteroid has a mass of $3.5 \times 10^{16} \text{ kg}$ and a radius of 8.8 km. What is the minimum speed needed to escape from the surface of this asteroid.
 - 23 m/s
 - 16 m/s
 - 520 m/s
 - 730 m/s
 - 810 m/s

4. A fisherman notices that his boat is moving up and down periodically without any horizontal motion, owing to waves on the surface of the water. It takes a time of 2.23 s for the boat to travel from its highest point to its lowest, a total distance of 0.660 m. The fisherman sees that the wave crests are spaced a horizontal distance of 5.81 m apart. How fast are the waves traveling?

- A) 4.90 km/h
- B) 4.69 km/h
- C) 6.62 km/h
- D) 9.38 km/h
- E) 10.9 km/h

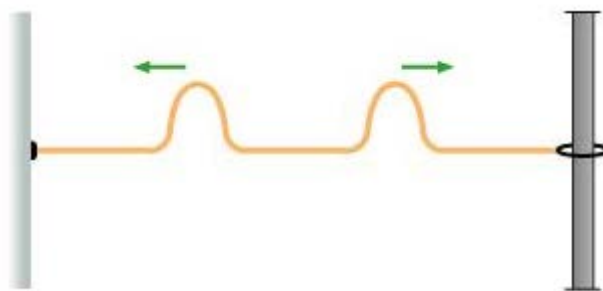
5. Consider a string of total length L , made up of three segments of equal length. The mass per unit length of the first segment is μ , that of the second segment is 3μ , and that of the third $\mu/4$. The third segment is tied to a wall, and the string is stretched by a force of magnitude T_s , applied to the first segment; T_s is much greater than the total weight of the string. How long will it take a transverse wave to propagate from one end of the string to the other?

- A) $L \sqrt{\frac{\mu}{T_s} \left(\frac{1}{2} + \frac{\sqrt{2}}{3} \right)}$
- B) $L \sqrt{\frac{\mu}{T_s} \left(\frac{1}{4} + \frac{\sqrt{2}}{3} \right)}$
- C) $L \sqrt{\frac{\mu}{T_s} \left(\frac{1}{2} + \frac{1}{\sqrt{3}} \right)}$
- D) $L \sqrt{\frac{\mu}{T_s} \left(\frac{1}{4} + \frac{1}{\sqrt{3}} \right)}$
- E) $L \sqrt{\frac{\mu}{T_s} \left(\frac{1}{5} + \frac{1}{\sqrt{3}} \right)}$

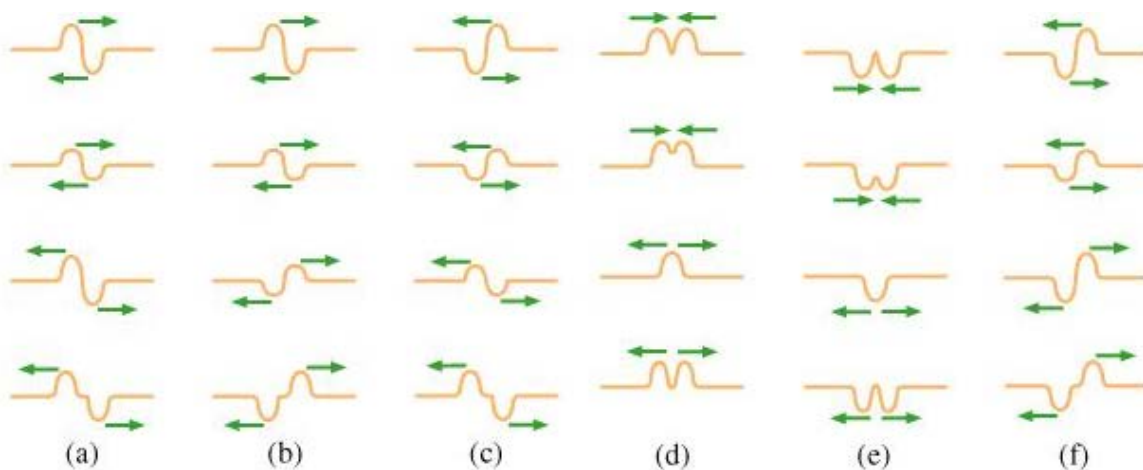
6. A piano tuner stretches a steel piano wire with a tension of 765 N. The steel wire has a length of 0.600 m and a mass of 4.15 g. What is the frequency of the string's fundamental mode of vibration?

- A) 266 Hz
- B) 254 Hz
- C) 246 Hz
- D) 272 Hz
- E) 277 Hz

7. Find the intensity of the sound waves produced by four 60.0-W speakers as heard by the driver. Assume that the driver is located 1.1 m from each of the two front speakers and 1.6 m from each of the two rear speakers.
- A) 11.6 W/m^2
 - B) 13.8 W/m^2
 - C) 12.9 W/m^2
 - D) 12.1 W/m^2
 - E) 10.7 W/m^2
8. Increasing the intensity of a sound by a factor of 100 causes the sound level to increase by what amount?
- A) 100 dB
 - B) 10 dB
 - C) 40 dB
 - D) 20 dB
 - E) 30 dB
9. A train is traveling at 30.0 m/s relative to the ground in still air. The frequency of the note emitted by the train whistle is 256 Hz. The speed of sound in air should be taken as 344 m/s. What frequency is heard by a passenger on a train moving at a speed of 18.0 m/s relative to the ground in a direction opposite to the first train and approaching it?
- A) 302 Hz
 - B) 228 Hz
 - C) 295 Hz
 - D) 289 Hz
 - E) 265 Hz



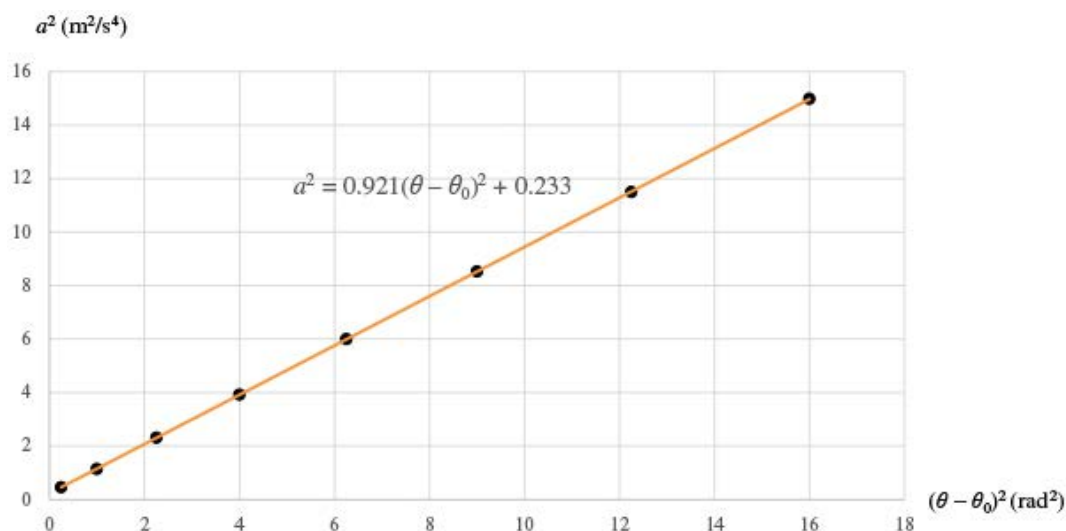
Two identical pulses are moving in opposite directions along a stretched string that has one fixed end and the other movable, as shown above. Above each pulse a green arrow indicates the direction of motion of the pulse. The two pulses reflect off the boundaries of the string, and at some later time, they pass through the middle of the string and interfere. Below are six different sequences of snapshots taken as the two pulses meet in the middle of the string. Time increases from top to bottom in each sequence.



Which sequence correctly represents the displacement of the string as the pulses interfere?

- A) (a)
- B) (b)
- C) (c)
- D) (d)
- E) (e)
- F) (f)

11.



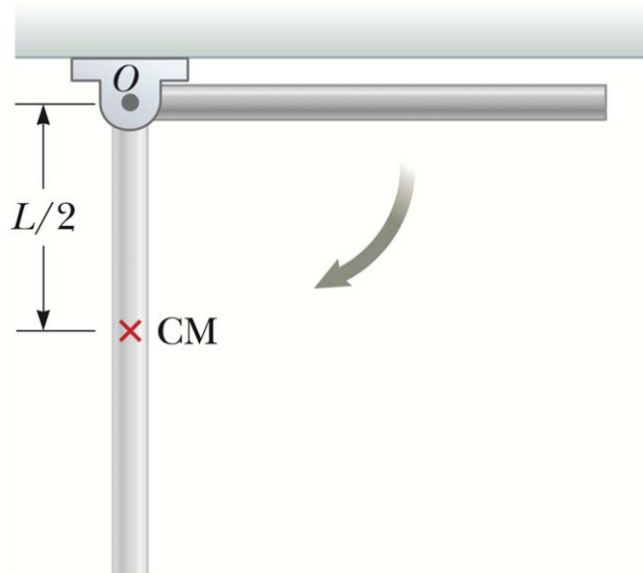
You are analyzing the motion of a large flywheel that has radius 0.960 m. In one test run, the wheel starts from rest and turns with constant angular acceleration. An accelerometer on the rim of the flywheel measures the magnitude of the resultant acceleration a of a point on the rim of the flywheel as a function of the angle $\theta - \theta_0$ through which the wheel has turned. You plot the measured data on the graph of a^2 (in m^2/s^4) versus $(\theta - \theta_0)^2$ (in rad^2) shown above. The graph is a straight line $a^2 = 0.921(\theta - \theta_0)^2 + 0.233$. Use the slope of the graph to find the angular acceleration of the flywheel.

- A) 0.600 rad/s^2
 B) 0.584 rad/s^2
 C) 0.557 rad/s^2
 D) 0.528 rad/s^2
 E) 0.500 rad/s^2
12. A spherical star rotates with a period of 30 days about an axis through its center. The period is the time interval required for a point on the star's equator to make one complete revolution around the axis of rotation. After the star undergoes a supernova explosion, the stellar core, which had a radius of 1.0×10^4 km, collapses into a spherical neutron star of radius 10.0 km. What is the period of rotation of the neutron star?
- A) 30 days
 B) 2.6 s
 C) 2.0 s
 D) 2.0 ms
 E) 2.6 ms

13. A section of hollow pipe and a solid cylinder have the same radius, mass, and length. They both rotate about their long central axes with the same angular speed. Which object has the higher rotational kinetic energy?

- A) The hollow pipe does.
- B) The solid cylinder does.
- C) They have the same rotational kinetic energy.
- D) It is impossible to determine.

14.

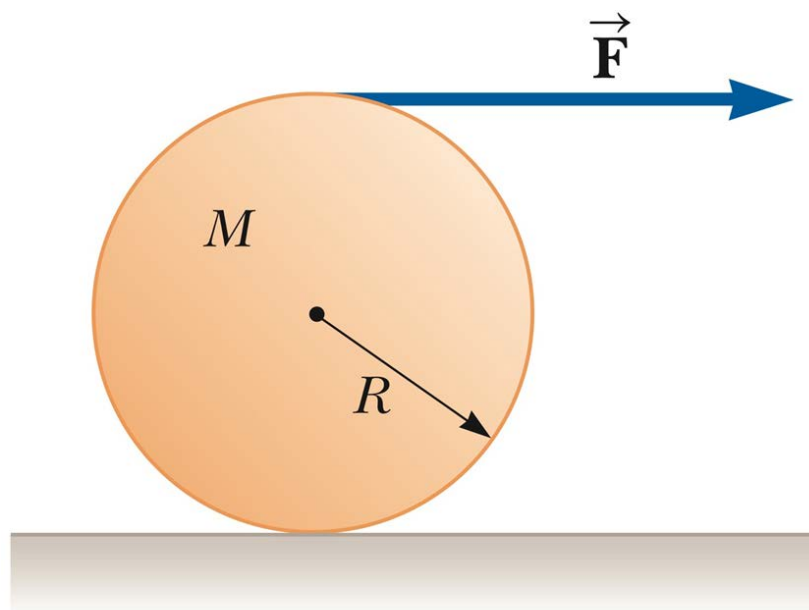


A uniform rod of length L and mass M is free to rotate on a frictionless pin passing through one end, as shown above. The rod is released from rest in the horizontal position. What is its angular speed when the rod reaches its lowest position?

- A) $\sqrt{\frac{3g}{2L}}$
- B) $\sqrt{\frac{g}{L}}$
- C) $2\sqrt{\frac{g}{L}}$
- D) $\sqrt{\frac{3g}{L}}$
- E) $3\sqrt{\frac{g}{L}}$

15.

7



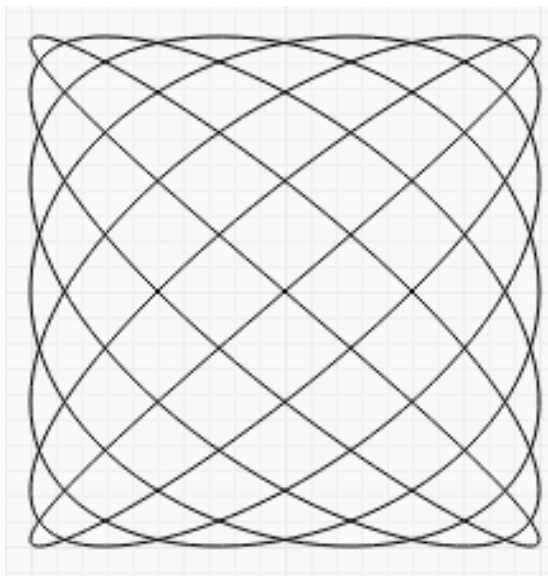
A spool of wire of mass M and radius R is unwound under a constant force \vec{F} , as shown above. Assuming the spool is a uniform, solid cylinder that does not slip, what is the acceleration of the center of mass?

- A) $\frac{3}{4M} \vec{F}$
- B) $\frac{4}{3M} \vec{F}$
- C) $\frac{4}{M} \vec{F}$
- D) $\frac{3}{M} \vec{F}$
- E) $\frac{2}{3M} \vec{F}$

16. A dentist's drill starts from rest. After 3.20 s of constant angular acceleration, it turns at a rate of 2.51×10^4 rev/min. Determine the angle (in radians) through which the drill rotates during this period.

- A) 3.21×10^3
- B) 3.54×10^3
- C) 3.71×10^3
- D) 4.93×10^3
- E) 4.21×10^3

17.

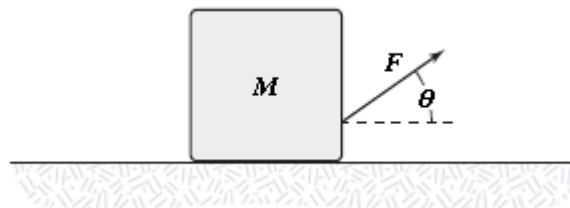


The Lissajous figure above is traced out by a point undergoing two independent simple harmonic motions, differing in phase by $\pi/2$, at right angles (along the horizontal x -axis and the vertical y -axis), with the corresponding angular frequencies ω_x and ω_y . This figure shows that the ratio $\omega_x:\omega_y$ is

- A) 7:6.
 B) 6:5.
 C) 5:4.
 D) 3:2.
 E) 2:1.
18. Calculate the torque about the origin of force $\mathbf{F} = (12.0 \text{ N})\hat{\mathbf{i}} + (4.00 \text{ N})\hat{\mathbf{j}} - (16.0 \text{ N})\hat{\mathbf{k}}$ applied at point A (2.00 m, -5.00 m, 7.00 m).
- A) $(52.0 \text{ N} \cdot \text{m})\hat{\mathbf{i}} - (116 \text{ N} \cdot \text{m})\hat{\mathbf{j}} - (68.0 \text{ N} \cdot \text{m})\hat{\mathbf{k}}$
 B) $-(52.0 \text{ N} \cdot \text{m})\hat{\mathbf{i}} + (116 \text{ N} \cdot \text{m})\hat{\mathbf{j}} + (68.0 \text{ N} \cdot \text{m})\hat{\mathbf{k}}$
 C) $(52.0 \text{ N} \cdot \text{m})\hat{\mathbf{i}} + (116 \text{ N} \cdot \text{m})\hat{\mathbf{j}} + (68.0 \text{ N} \cdot \text{m})\hat{\mathbf{k}}$
 D) $-(52.0 \text{ N} \cdot \text{m})\hat{\mathbf{i}} - (116 \text{ N} \cdot \text{m})\hat{\mathbf{j}} + (68.0 \text{ N} \cdot \text{m})\hat{\mathbf{k}}$
 E) $(52.0 \text{ N} \cdot \text{m})\hat{\mathbf{i}} + (116 \text{ N} \cdot \text{m})\hat{\mathbf{j}} - (68.0 \text{ N} \cdot \text{m})\hat{\mathbf{k}}$
19. A certain gyroscope precesses at the rate of 0.40 rad/s when used on earth. If it were taken to a lunar base, where the acceleration due to gravity is 0.165g, what would be its precession rate?
- A) 0.0825 rad/s
 B) 0.0785 rad/s
 C) 0.0750 rad/s
 D) 0.0705 rad/s
 E) 0.0660 rad/s

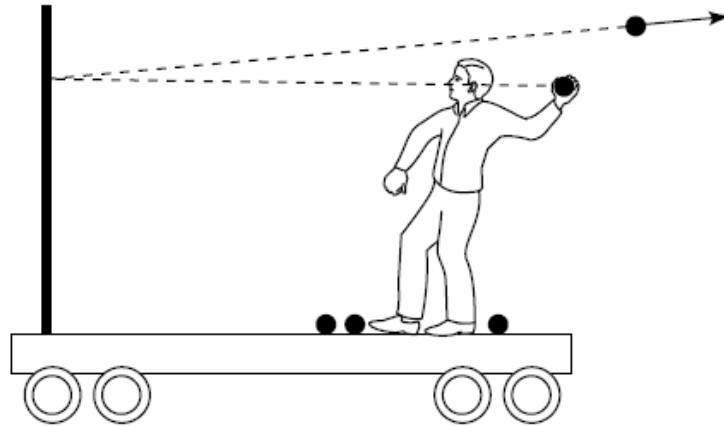
20. If you drive a car at constant speed of 10.00 m/s such that the wheels do not slip, then
- A) the speed at the bottom of the wheel (while in contact with the ground) is -10.00 m/s.
 - B) the velocity of a point on the wheel at the same height as the center of mass of the wheel is 10.00 m/s and points either up or down.
 - C) the speed of a point on the wheel at the same height as the center of mass of the wheel is 14.14 m/s.
 - D) the acceleration of the point at the top of the wheel is zero.
 - E) the acceleration of the point at the bottom of the wheel is zero.
21. The blades of a plane propeller need to be designed such that the top speed of the blade tip is just under the speed of sound. When the maximum engine speed is 7000 rev/min, determine what length the blade should be. Take the speed of sound to be 340 m/s.
- A) 46.4 cm
 - B) 49.1 cm
 - C) 52.3 cm
 - D) 54.2 cm
 - E) 43.7 cm
22. A golf ball with a mass of 46.0 g strikes a wall horizontally at a speed of 130 km/h and bounces straight back from the wall with the same speed. The collision takes 0.900 ms. The magnitude of the average force experienced by the ball during the collision is
- A) 1.85 kN.
 - B) 2.17 kN.
 - C) 2.84 kN.
 - D) 3.69 kN.
 - E) 3.91 kN.
23. A 100-g marble is moving to the right at a speed of 3.00 m/s. It undergoes an elastic collision with a 200-g marble moving to the left at a speed of 4.00 m/s. Find the speed of the 100-g marble after the collision.
- A) 0.667 m/s
 - B) 6.33 m/s
 - C) 5.21 m/s
 - D) 0.512 m/s
 - E) 3.24 m/s

24. A depth sounder on a boat sends out the pulse and listens for the echo from the bottom. The water is 30 m deep and the speed of sound in water is 1482 m/s. How long will it take for the echo to come back?
- A) 20 ms
B) 25 ms
C) 31 ms
D) 36 ms
E) 40 ms
25. You tie a cord to a pail of water and swing the pail in a vertical circle of radius 62.5 cm. What minimum speed must you give the pail at the highest point of the circle to avoid spilling water?
- A) 2.42 m/s
B) 2.76 m/s
C) 2.47 m/s
D) 2.13 m/s
E) 2.87 m/s
26. A damped oscillator is released from rest with an initial displacement of 10.00 cm. At the end of the first complete oscillation the displacement reaches 9.05 cm. When four more oscillations are completed, what is the displacement reached?
- A) 6.71 cm
B) 6.52 cm
C) 6.37 cm
D) 6.07 cm
E) 5.77 cm
- 27.



The block shown is pulled across the horizontal surface at a constant speed by the force shown. If $M = 5.0$ kg, $F = 14$ N, and $\theta = 35^\circ$, what is the coefficient of kinetic friction between the block and the horizontal surface?

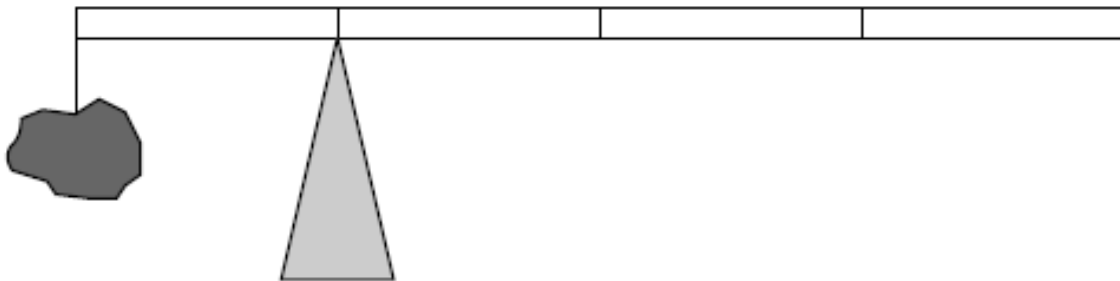
- A) 0.23
B) 0.28
C) 0.32
D) 0.36
E) 0.40



Suppose you are on a cart that is initially at rest on a track with very little friction. You throw balls at a partition that is rigidly mounted on the cart. If the balls bounce straight back as shown in the figure, is the cart put in motion?

- A) Yes, it moves to the left.
- B) Yes, it moves to the right.
- C) No, it remains in place.

29.



A 1.0-kg rock is suspended by a massless string from one end of a 1.0-m measuring stick. What is the mass of the measuring stick if it is balanced by a support force at the 0.25-m mark? Assume the stick has uniform density.

- A) 4.0 kg
- B) 2.0 kg
- C) 1.0 kg
- D) 0.5 kg
- E) 0.25 kg

30. We want to hang a thin hoop on a horizontal nail and have the hoop make one complete small-angle oscillation each 2.14 s. What must the hoop's radius be?
- A) 11.4 cm
 - B) 14.2 cm
 - C) 28.4 cm
 - D) 56.8 cm
 - E) 114 cm
31. In designing buildings to be erected in an area prone to earthquakes, which relationship should the designer try to achieve between the natural frequency of the building and the typical earthquake frequencies?
- A) The natural frequency of the building should be exactly the same as typical earthquake frequencies.
 - B) The natural frequency of the building should be very different from typical earthquake frequencies.
 - C) The natural frequency of the building should be almost the same as typical earthquake frequencies but slightly higher.
 - D) The natural frequency of the building should be almost the same as typical earthquake frequencies but slightly lower.