PHY2048 Spring 2018 Exam 3 Review Questions

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Chapter 9: Gravity

1. What is the escape velocity of a planet whose mass is twice that of the Earth, and whose radius is half that of Earth's? Note that the escape velocity of Earth is 11.2 km/s.

   (a) 5.6 km/s

   (b) 11.2 km/s

   (c) 22.4 km/s

   (d) 44.8 km/s

2. At what altitude must a satellite be placed in order for its weight to be one-fourth that on the surface of Earth? Note that the radius of Earth is $R_E = 6400$km.

   (a) $R_E/2$

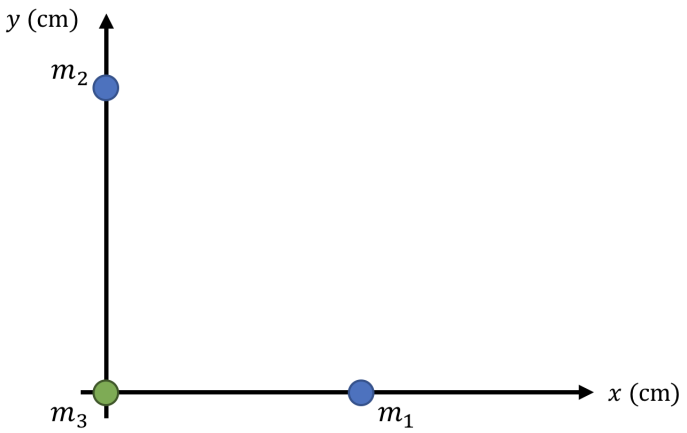
   (b) R_E

   (c) $2R_E$

   (d) $4R_E$

3. Two masses, $m_1 = 15.2$kg and $m_2 = 24.7$kg, are separated by $d = 2.8$cm. What is the magnitude of the gravitational force on each mass?

4. Two masses, $m_1 = 3.5$kg and $m_2 = 1.6$kg, are placed at the (x, y) coordinates (1.5cm, 0) and (0, 2.5cm), as shown in the figure. A third mass, $m_3 = 2.8$kg, is placed at the origin.



(a) What is the net gravitational force on m_3?

(b) In what direction does this gravitational force point?

(c) If m_1 and m_2 are fixed in place, and m_3 moves from (0,0) to (0.5cm, 1.7cm), how much work is done by the gravitational force?

5. Two masses, $m_1 = 1.2$kg and $m_2 = 1.7$kg, are separated by a distance $d = 10.3$cm on the x-axis. A third mass, $m_3 = 2.5$kg, is placed on the x-axis such that the net gravitational force on m_3 is zero. Where must m_3 be placed for this to be true?

6. How far above the surface of the Earth must a satellite be placed so that the gravitational acceleration on that satellite is 2 m/s^2?

7. What is the altitude of a geosynchronous satellite? Note that a geosynchronous orbit is one that moves with the same period as the Earth, so that it's always above the same position on the ground.

8. Imagine a pitcher had a baseball of mass 145g. If the pitcher wanted to throw the ball fast enough so that it fell into a stable orbit at a height of 2m (roughly the height of the pitcher) above the ground, how fast must he throw the ball? Note that the mass of the Earth is 5.97×10^{24} kg, and the radius of the Earth is 6400km.

9. A black hole will be created if the escape velocity of a star becomes greater than the speed of light. The radius above the surface of the black hole at which this occurs is known as the Schwarzchild radius. What would the Schwarzchild radius of the Sun be? Note that the mass of the Sun is 1.99×10^{30} kg, and the radius is 700,000km. This computation will illustrate to you exactly how far the Sun must collapse in on itself in order to become a black hole.

Chapter 15: Oscillations

1. A mass-spring system whose period on Earth is 1s will have a period on the Moon of what? Note that the mass of the Moon is 7.35×10^{22} kg, and the radius is 1737km.

   (a) 0.167 s

   (b) 1s

   (c) 2.45s

   (d) 6s

2. A 0.5kg mass oscillates on a spring with a force constant of 150 N/m. If the spring is stretched by 2cm, and released from rest, what is the amplitude of the mass' oscillations?

   (a) 1cm

   (b) 2cm

   (c) 3cm

   (d) 4cm

3. A 2kg mass is attached to a spring with a force constant of 98 N/m. Initially at the equilibrium position of the spring, and at rest, the mass is hit such that it gains a momentum of 20 Ns. What, now, will be the amplitude of the mass' oscillation?

   (a) 0.2m

   (b) 1.43m

   (c) 2.86m

   (d) 4.29m

4. A mass m undergoes horizontal oscillations attached to a spring of constant k, with an amplitude of A and a maximum speed of v_{max}. Draw the mass-spring system at important points in its motion, making sure to indicate (a) where the mass is at its amplitude of oscillation, (b) where the mass has its minimum speed, (c) where the mass has its maximum speed, (d) where the mass feels a minimum force due to the spring, (e) where the mass feels a maximum force due to the spring, and (f) the equilibrium position of the mass. Include as many points in your drawing as you need to indicate where (a) - (f) occur in the motion of the mass.

5. A 1.3kg mass is attached to a spring with a force constant of 120 N/m, and allowed to oscillate horizontally. Initially, the mass is stretched by 4cm, and released from rest.

   (a) What is the total energy of the mass? Assume that $y = 0$ when calculating the gravitational potential energy of the mass.

   (b) What is the maximum potential energy of the mass? The maximum kinetic energy?

   (c) What is the amplitude of the oscillations?

   (d) What is the maximum speed of the mass?

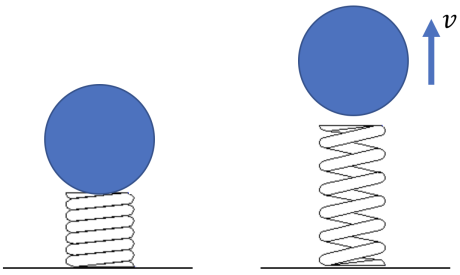
6. A 2.5kg mass is attached to a spring with a force constant of 180 N/m, and is allowed to hang vertically. Assume that the spring has a natural length of 25cm.

   (a) When at rest, what is the total length of spring at equilibrium?

   (b) If the mass is stretched by 2cm from the vertical equilibrium point, what will be the maximum length of spring during oscillation? What will be the minimum length?

   (c) What is the period of oscillations for the spring undergoing the motion described in part (b)?

7. A 2.7kg mass rests on a vertically-oriented spring of constant 250 N/m, such that the mass **is not attached** to the spring; this allows the mass to be launched upward from the spring, as shown in the following figure.

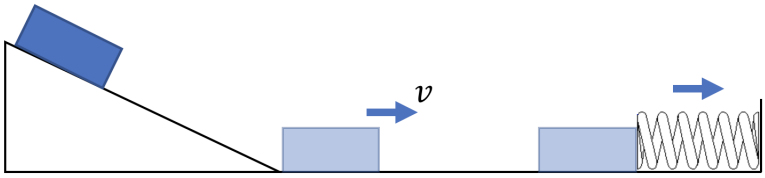


(a) If the spring is compressed by 12.5cm from its natural length, and the spring has a natural length of 25cm, at what height does the mass lose contact with the spring? Assume that $y = 0$ is at the base of the spring.

(b) At what speed would the ball leave the spring with?

(c) What would the maximum height of the ball be?

8. A 1.2kg mass slides down a frictionless incline of height 0.15m, moves along a horizontal, frictionless surface, and then impacts a spring of constant 140N/m, causing it to compress. This process is shown in the following figure.



(a) What speed does the mass impact the spring with?

(b) What would the total energy of the mass-spring system be?

(c) What would the maximum compression of the spring be?

Chapter 16: Waves

1. The speed of light in any medium is $v = c/n$, where $c = 3 \times 10^8$ m/s is the speed of light in a vacuum, and n is the index of refraction of the medium. A beam of light in air has a 750nm wavelength when it moves into water. What would the wavelength be in water? Note $n_{air} = 1$ and $n_{water} = 1.33$.

(a) 564nm

(b) 650nm

(c) 750nm

(d) 998nm

2. A mechanical wave on a string vibrates with a frequency of 100 Hz when it passes from one string to another. If the mass per unit length μ of the string doubles, but the tension T remains the same, what would the frequency of the wave be along the new string? Note that the velocity of a mechanical wave on a string is $v = \sqrt{T/\mu}$.

(a) 25 Hz

(b) 50 Hz

(c) 71 Hz

(d) 100 Hz

3. Two speakers play different sounds: one speaker plays a known sound at 500 Hz, and the other speaker plays an unknown sound. However, when you listen to both speakers at the same time, you hear a beat frequency of 20 Hz. What is the frequency of the unknown speaker?

   (a) 480 Hz

   (b) 520 Hz

   (c) Either 480 Hz or 520 Hz

   (d) 500 Hz

4. The range of human hearing is from 20 Hz to 20 kHz. If the speed of sound in air is 350 m/s, what is the range of all possible wavelengths that humans can hear?

5. A tsunami is a giant wave produced in the water. If a satellite observes a tsunami to be moving such that the distance from one wave crest to another is 800km, and it takes 1 hour for one wave crest to be replaced by the next, what is:

   (a) The wavelength of the tsunami?

   (b) The frequency of the tsunami?

   (c) The wave speed of the tsunami?

6. Two sources of sound are playing near you, one with a wavelength $\lambda_1 = 0.233$m and the other with an unknown wavelength λ_2. Note that the speed of sound is 350m/s in air.

   (a) What is the frequency of sound 1, f_1?

   (b) If you listen to both sources at the same time, you hear a beat frequency of 100 Hz. What are the possible wavelengths of the unknown source of sound, λ_2?

   (c) Say someone changes the second source, so that λ_2 decreases. You notice at the same time that the beat frequency you hear gets larger. What, then, was λ_2 originally?

   (d) If you heard both of these sources underwater, where the speed of sound is 1500 m/s, what beat frequency would you hear?

Chapter 19 & 20: Heat & the Ideal Gas Law

1.

Chapter 21: Thermodynamics

1.