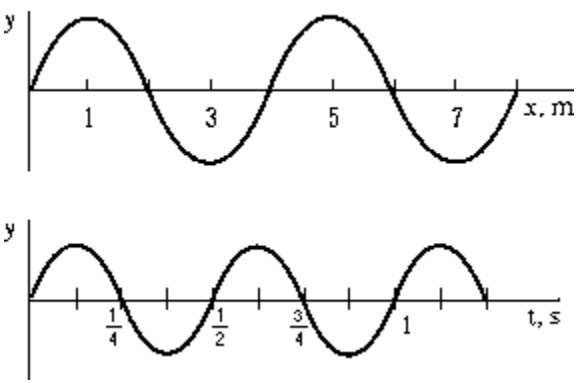
INSTRUCTIONS: Write your NAME and your LECTURE (01: 8:30/Eskildsen, 02: 10:40/Goussiou, 03: 3:00/Bunker) on the front of the blue exam booklet. The exam is closed book, and you may have only pens/pencils and a calculator (no stored equations or programs and no graphing). Show all of your work in the blue book. For problems II-VI, an answer alone is worth very little credit, even if it is correct – so show how you get it. **Please enter the multiple-choice answers in the stamped form on the first inside page of the exam.**

Suggestions: Draw a diagram when possible, circle or box your final answers, and cross out parts which you do not want us to consider.

I. **Multiple Choice Questions**

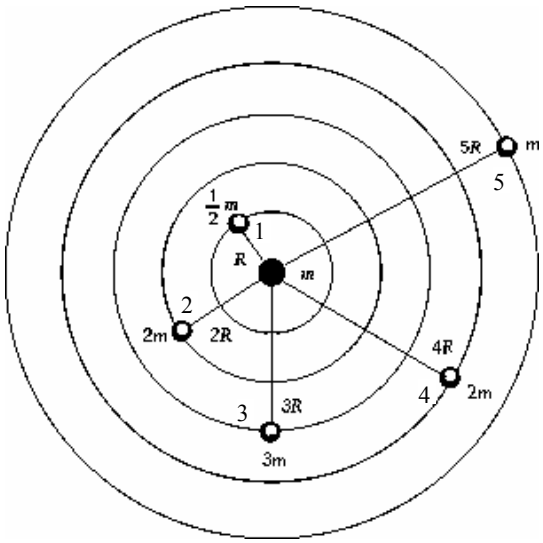
1. A wave is traveling with a speed v along the x axis in the positive direction. The upper graph shows the displacement y versus the distance x for a given instant of time. The lower graph shows the displacement y versus the time t for any given point x. From the information in the graphs, what is the wave speed v?



   A) 8.0 m/s
   B) 4.0 m/s
   C) 6.0 m/s
   D) none of the above
   E) not enough information

2. Of the five masses in orbit around the central mass, the one with the longest period of revolution is

   A) 1 B) 2 C) 3 D) 4 E) 5



3. Two carts with masses $m_1 < m_2$ are placed on an airtrack and can move horizontally without friction. Initially cart 2 is at rest and cart 1 approaches with velocity v_0 as shown in the figure.

After undergoing an elastic collision:

A) The two carts move to the right with a common velocity $v = v_0$.
B) The two carts move to the right with a common velocity $v < v_0$.
C) Both move to the right but with different velocities
D) Cart 1 stops and cart 2 moves to the right with velocity v_0.
E) Cart 1 moves to the left and cart 2 moves to the right.

4. A particle is launched from the surface of the earth with a speed three times the escape speed (v_{esc} = 11.2 km/s). When it is very far from the earth, what is its speed?

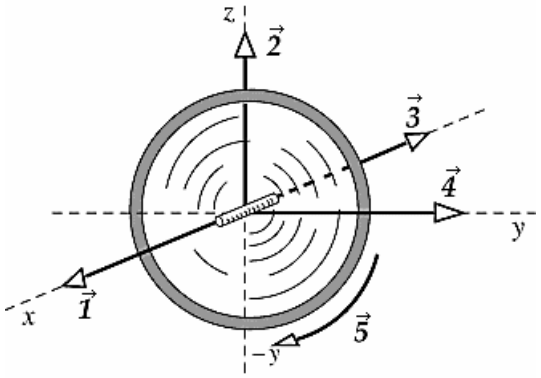
A) 0 km/s
B) 11.2 km/s
C) 22.4 km/s
D) 31.7 km/s
E) 33.6 km/s

5. A block of wood with a mass M = 4.65 kg is resting on a horizontal surface when a bullet with a mass m = 18 g and moving with a speed v = 725 m/s strikes it and gets embedded in the block. The coefficient of kinetic friction between the block and the surface is μ_k = 0.35. The distance the block moves across the surface is

A) 1.1 m
B) 3.3 m
C) 0.41 m
D) 11 m
E) None of these is correct.

6. A wheel is rotating clockwise on a fixed axis perpendicular to the page (x). A torque that causes the wheel to slow down is best represented by the vector

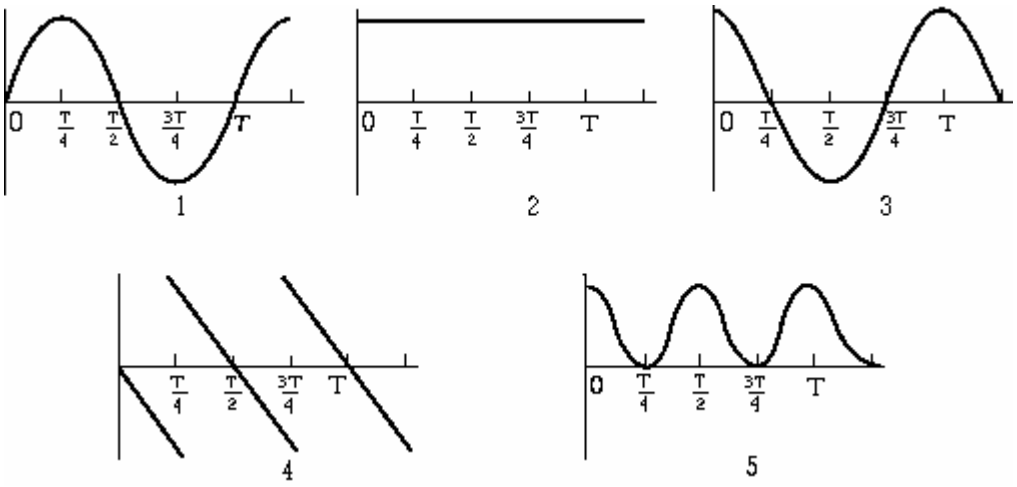
A) $\vec{1}$ B) $\vec{2}$ C) $\vec{3}$ D) $\vec{4}$ E) $\vec{5}$



7. A turntable has an angular velocity of 1.4 rad/s. The coefficient of static friction between the turntable and a block placed on it is $\mu_s = 0.20$.

   The maximum distance from the center of the turntable that the block can be placed without sliding is approximately

   A) 0.5 m
   B) 1.0 m
   C) 1.4 m
   D) 2.0 m
   E) 4.4 m

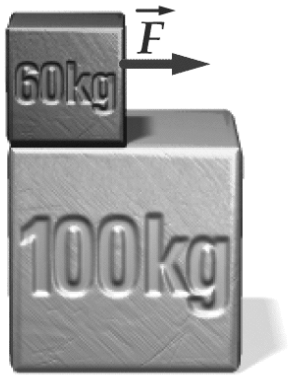
8. 

   The kinetic energy of a body executing simple harmonic motion is plotted against time expressed in terms of the period *T*. At $t = 0$, the displacement is zero. Which of the graphs most closely represents these conditions?

   A) 1 B) 2 C) 3 D) 4 E) 5

Problems

II. A block of mass $m_1 = 60$ kg slides along the top of a block of mass $m_2 = 100$ kg. There is no friction between the 100-kg block and a frictionless horizontal surface, but there ***is*** friction between the two blocks.



When a horizontal force $\vec{F}$ of 320 N is applied to the 60-kg block, the block has an acceleration of 3 m/s^2.

(a) Draw free body diagrams for the two blocks.

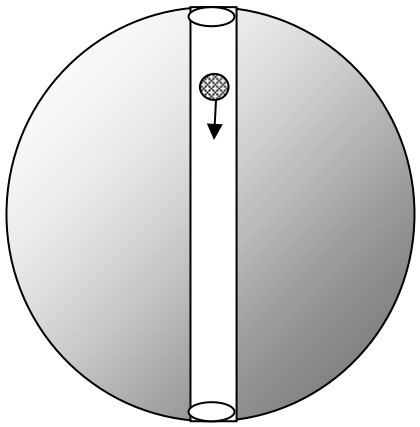
(b) Write Newton's 2nd law in the horizontal and vertical direction for the block of mass m_1.

(c) Write Newton's 2nd law in the horizontal and vertical direction for the block of mass m_2.

(d) Find the coefficient of kinetic friction between the blocks.

(e) Find the acceleration of the 100-kg block during the time that the 60-kg block remains in contact.

III. Ganymede, one of Jupiter's moons, has a radius of 2631 km and has a mean density $\rho = 1.9$ g/cm^3. Assume that Ganymede is spherical, the density is uniform, and ignore rotation of the moon.



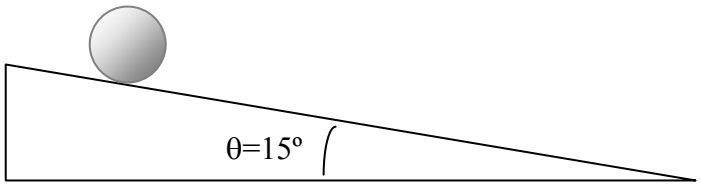
a) What is the gravitational field at the surface of Ganymede?

If a shaft were drilled all the way through the moon, passing through the center of the moon,

b) what would be gravitational field as a function of distance from the center of the moon, for distances less than the moon's radius?

c) what would be the oscillation frequency (in Hz) of an object dropped from the surface through the shaft and passing through the moon's center?

IV. A 0.6 kg basketball rolls without slipping down an incline of angle $\theta = 15°$. The radius of a standard basketball is 11.4 cm, and it can be treated as if all of its mass is in a thin shell at the surface.



a) Draw free-body diagram, showing all forces acting on the basketball.

b) Write down Newton's 2nd Law for translation of the cylinder.

c) Write down Newton's 2nd Law for rotation of the cylinder, and relate the angular acceleration to the linear acceleration.

d) Determine the acceleration of the center of mass of the basketball.

e) Find the frictional force acting on the ball.

V. A damped oscillator loses 5% of its energy during each cycle.

a) How many cycles elapse before half of the initial energy is dissipated?

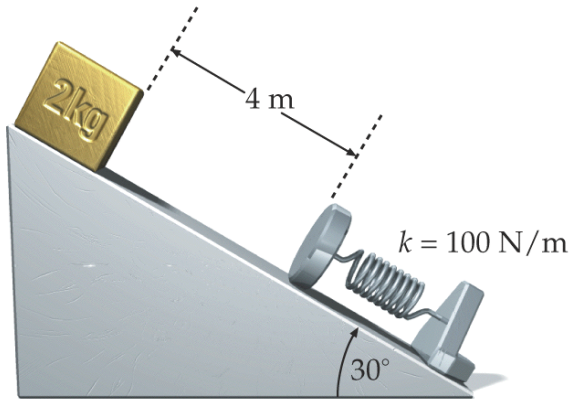
b) What is the quality factor (Q factor) of the oscillator?

c) If the natural frequency is 120 Hz, what is the width of the resonance curve when the oscillator is driven?

VI. A 2-kg block is released 4 m from a massless spring with force constant $k = 100$ N/m that is along a plane inclined at 30°.

(a) If the plane is frictionless, find the maximum compression of the spring.

(b) If the coefficient of kinetic friction between the plane and the block is $\mu_k = 0.2$, find the maximum compression of the spring.



VII. A loudspeaker at a rock concert generates an intensity of 10^{-3} W/m^2 at 100 m. Assume that the speaker spreads its energy uniformly in all directions.

a) What is the acoustic power emitted by the loudspeaker?

b) What is the intensity level at 30 m?