ACP Physics Exam

Final Exam

This exam consists of a 10-question multiple-choice section worth 50 points and two problems each worth 25 points. Show all your work on these sheets.

You may use your calculators and a one-page summary of relevant formulae.

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Part I

Question 1 (5 points)

The potential energy of a body of mass m is given by: $U = -mgx + kx^2 / 2$. The corresponding force on this body is:

(a) $-mgx^2 / 2 + kx^3 / 6$
(b) $mgx^2 / 2 - kx^3 / 6$
(c) $-mg + kx / 2$
(d) $mg + kx / 2$
(e) $mg - kx$

Question 2 (5 points)

A source of 1-kHz sound is moving straight toward you at 0.9 times the speed of sound. The frequency you detect is:

(a) 0.1 kHz
(b) 0.5 kHz
(c) 1.1 kHz
(d) 1.9 kHz
(e) 10 kHz

Question 3 (5 points)

A 5-kilogram stone is dropped on a nail and drives the nail 25 cm into a piece of wood. If the stone is moving at 10 m/sec when it hits the nail, the average force exerted on the nail by the stone is most nearly:

(a) 10 N
(b) 100 N
(c) 1,000 N
(d) 10,000 N
(e) 100,000 N

Question 4 (5 points)

A rock is thrown vertically upward with initial speed v_o. Assume a friction force proportional to - **v**, that is, always anti-parallel to the velocity vector of the rock. Neglecting any buoyant force exerted by the air, which of the following statements is correct?

(a) The acceleration of the rock is always equal to **g**
(b) The acceleration of the rock equal to **g** only at the highest point reached by the rock
(c) The acceleration of the rock is always less than **g**
(d) The speed of the rock on return to its starting point is v_o
(e) The acceleration of the rock is always greater than **g**

Question 5 (5 points)

A particle is constrained to move along the x-axis under the influence of a net force $F = -k\ x$ (k is a positive constant) with amplitude A and frequency f. When $x = A / 2$, the speed of the particle is:

(a) $2\pi fA$
(b) $\sqrt{3}\pi fA$
(c) $\sqrt{2}\pi fA$
(d) πfA
(e) $\pi fA / 3$

Question 6 (5 points)

A blackbody at temperature T_1 radiates energy at a power level of 10 milliwatts (mW). The same blackbody, at temperature $2\ T_1$ radiates energy at a power level of:

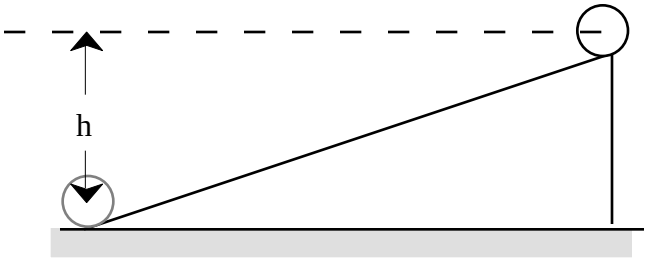
(a) 10 mW
(b) 20 mW
(c) 40 mW
(d) 80 mW
(e) 160 mW

Question 7 (5 points)

In each cycle of a Carnot engine, 100 joules of heat is absorbed from the high-temperature reservoir and 60 joules is exhausted to the low-temperature reservoir. The efficiency of the engine is:

(a) 40%
(b) 60%
(c) 67%
(d) 150%
(e) 167%

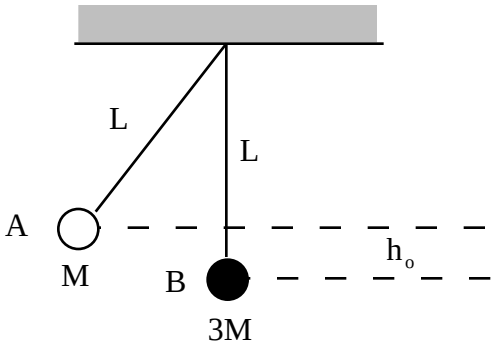
Question 8 (5 points)



A hoop of mass M and radius R is a rest at the top of an incline as shown. The hoop rolls down the plane without slipping. When the hoops reaches bottom, its angular momentum about its center of mass is:

(a) $MR\sqrt{gh}$
(b) $MR\sqrt{gh}\ /\ 2$
(c) $M\sqrt{2gh}$
(d) Mgh
(e) $Mgh\ /\ 2$

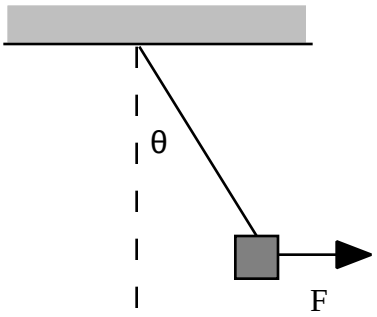
Question 9 (5 points)



Two spheres of putty, A and B, of mass M and 3M respectively, hang from the ceiling on strings of length L. Sphere A is drawn aside so that it is raised to a height h_o ,as shown in the figure above, and then released. Sphere A collides with sphere B; they stick together and swing to a maximum height h, equal to:

(a) $h_o\ /\ 16$
(b) $h_o\ /\ 8$
(c) $h_o\ /\ 4$
(d) $h_o\ /\ 3$
(e) $h_o\ /\ 2$

Question 10 (5 points)

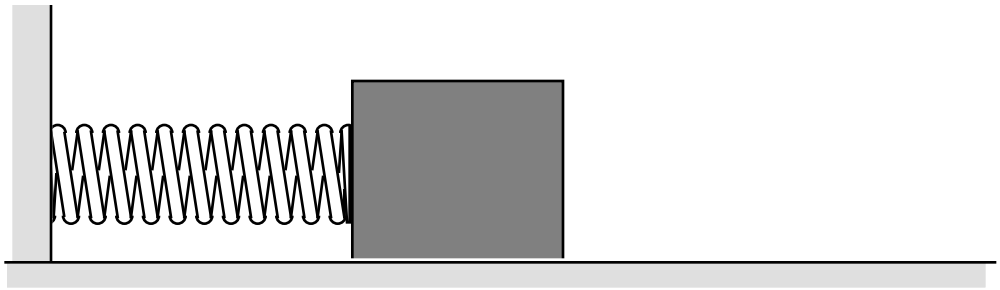


A 2-kilogram box hangs by a massless rope from a ceiling as shown. A force slowly pulls the box horizontally to the side until the force is equal to 10 N. The box is then in equilibrium. The angle that the rope makes with the vertical is closest to:

(a) arctan(0.5)
(b) arcsin(0.5)
(c) arctan(2.0)
(d) arcsin(2.0)
(e) 45^o

Part II

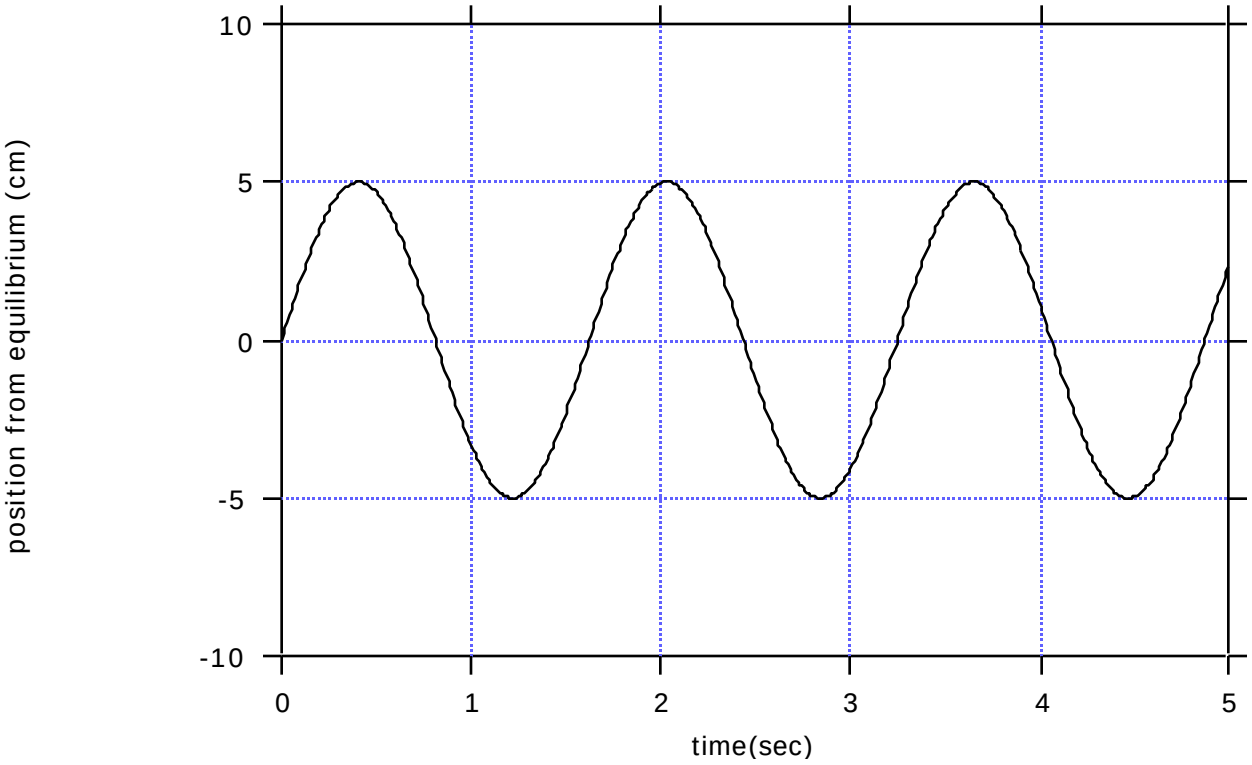
Problem 1 (25 points) A spring is attached to a rigid wall on one end and to a 2.0-kilogram mass on the other end. The mass moves without friction on a level surface. The mass is set into oscillation at $t = 0$. The plots of position as measured from equilibrium vs time and velocity vs time are shown in the plots on the following page.



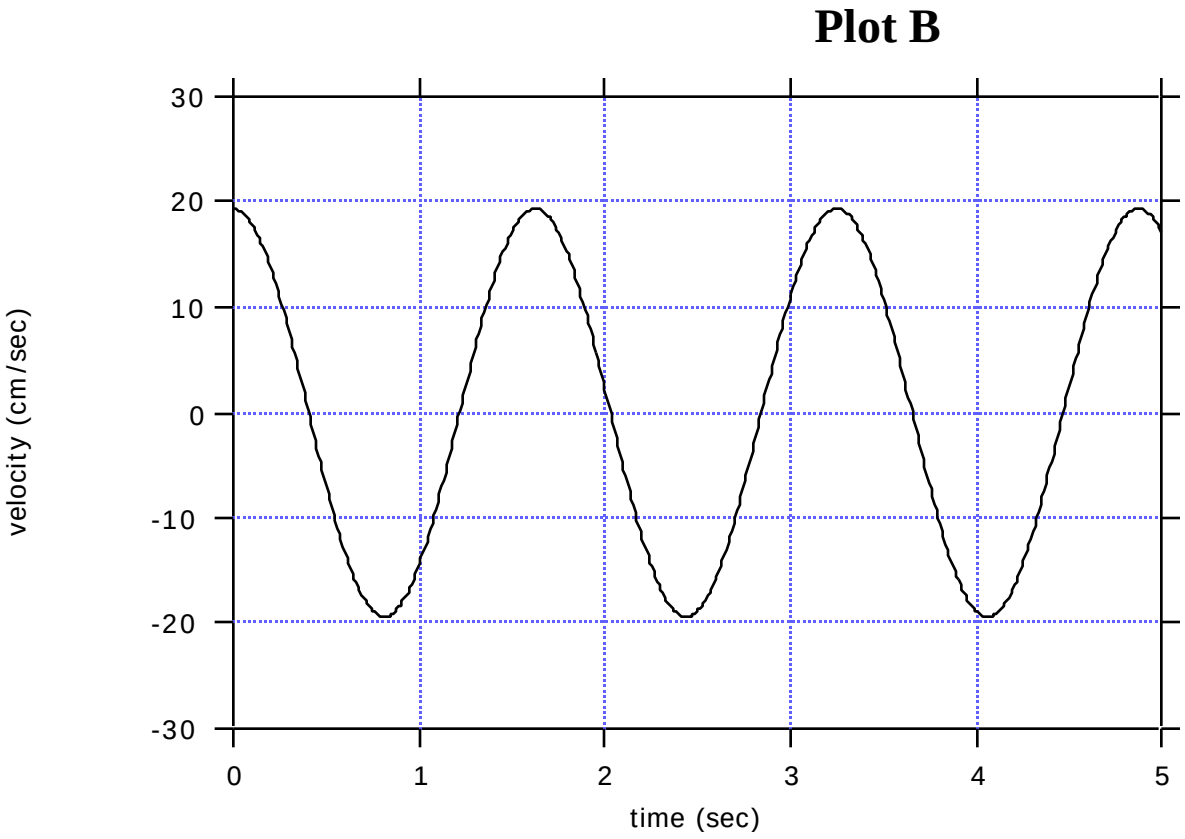
(a) What is the frequency of oscillation?

(b) What is the spring constant in N/m ?

Plot A


position from equilibrium (cm)
10
5
0
-5
-10
0
1
2
3
4
5
time(sec)

Plot B


velocity (cm/sec)
30
20
10
0
-10
-20
-30
0
1
2
3
4
5
time (sec)

(c) What is the initial potential energy?

(d) What is the initial kinetic energy?

(e) On plot A, sketch the acceleration of the mass vs time and be sure to indicate the units and numbers on the vertical axis on the right of the plot.

Problem 2 (25 points)

A satellite is in geosynchronous circular orbit above a point on the Earth's equator. The satellite is equipped with rockets which can provide a thrust parallel to or anti-parallel to its direction of motion. The radius of the Earth is 6.4×10^3 km.

(a) How high above the Earth's surface is the satellite?

(b) What is the velocity of the satellite?

(c) The thrusters are fired for a period of time anti-parallel to the direction of motion and the satellite is now in an new circular orbit which is lower, i.e. the radius of the orbit is now 3/4 of the radius for the goesychronous orbit. What is the new velocity?