Problem 1:

The period of a hypothetical Earth satellite orbiting at sea level would be 80 minutes. In terms of the Earth's radius R_e, the radius of a synchronous satellite orbit (period 24 hours) is most nearly

(A) $3\ R_e$

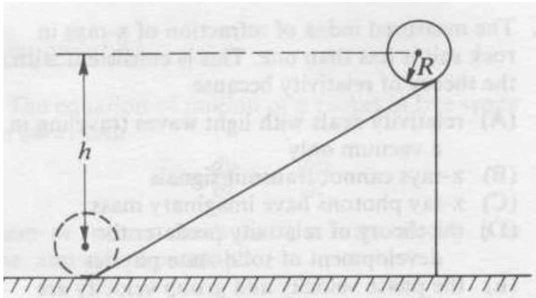
(B) $7\ R_e$

(C) $18\ R_e$

(D) $320\ R_e$

(E) $5800\ R_e$

Problem 2:



A hoop of mass M and radius R is at rest at the top of an inclined plane as shown above. The hoop rolls down the plane without slipping. When the hoop reaches the bottom, its angular momentum around its center of mass is

(A) $MR\sqrt{gh}$

(B) $\frac{1}{2}MR\sqrt{gh}$

(C) $M\sqrt{2gh}$

(D) Mgh

(E) $\frac{1}{2}Mgh$

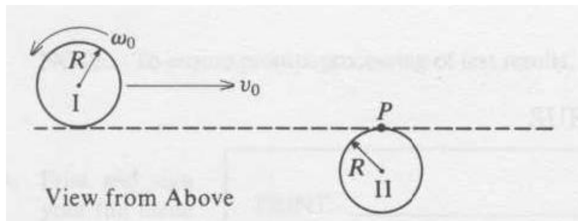
Problem 3:

A particle is constrained to move along the x-axis under the influence of the net force $\mathbf{F} = -k\mathbf{x}$ with amplitude A and frequency f, where k is a positive constant. When $x = A/2$, the particle's speed is

(A) $2\pi fA$ (B) $\sqrt{3}\pi fA$ (C) $\sqrt{2}\pi fA$

(D) πfA (E) $\frac{1}{3}\pi fA$

Problem 4:



Two uniform cylindrical disks of identical mass M, radius R, and moment of inertia $\frac{1}{2}MR^2$, as shown above, collide on a frictionless, horizontal surface. Disk I, having an initial counterclockwise angular velocity ω_0 and a center-of-mass velocity $v_0 = \frac{1}{2}\omega_0 R$ to the right, makes a grazing collision with disk II initially at rest. If after the collision the two disks stick together, the magnitude of the total angular momentum about the point P is

(A) zero

(B) $\frac{1}{2}MR^2\omega_0$

(C) $\frac{1}{2}MRv_0$

(D) MRv_0

(E) dependent on the time of the collision

Problem 5:

A particle of mass m that moves along the x-axis has potential energy $V(x) = a + bx^2$, where a and b are positive constants. Its initial velocity is v_0 at $x = 0$. It will execute simple harmonic motion with a frequency determined by the value of

(A) b alone
(B) b and a alone
(C) b and m alone
(D) b, a, and m alone
(E) b, a, m, and v_0

Problem 6:

The equation of motion of a rocket in free space can be written

$$m \frac{dv}{dt} + u \frac{dm}{dt} = 0$$

where m is the rocket's mass, v is its velocity, t is time, and u is a constant.

The constant u represents the speed of the

(A) rocket at $t = 0$
(B) rocket after its fuel is spent
(C) rocket in its instantaneous rest frame
(D) rocket's exhaust in a stationary frame
(E) rocket's exhaust relative to the rocket

Problem 7:

The equation of motion of a rocket in free space can be written

$$m \frac{dv}{dt} + u \frac{dm}{dt} = 0$$

where m is the rocket's mass, v is its velocity, t is time, and u is a constant.

The equation can be solved to give v as a function of m. If the rocket has $m = m_0$ and $v = 0$ when it starts, what is the solution?

(A) $u\, m_0/m$
(B) $u \exp(m_0/m)$
(C) $u \sin(m_0/m)$
(D) $u \tan(m_0/m)$
(E) None of the above.

Problem 8:

The weight of an object on the Moon is 1/6 of its weight on the Earth. A pendulum clock that ticks once per second on the Earth is taken to the Moon. On the Moon the clock would tick once every

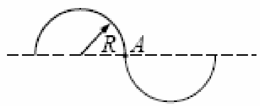
(A) 1/6 s.
(B) $(1/6)^{1/2}$ s.
(C) 1 s.
(D) $6^{1/2}$ s.
(E) 6 s.

Problem 9:

The potential energy function representing the attractive central force field can be written as $V(r) = -k/r$. At a certain time the particle has angular momentum **L** and total energy E.
At some later time, which of the following statements will be true of the angular momentum **L** and total energy E of the particle?

(A) **L** will have changed, but E will not.
(B) E will have changed, but **L** will not.
(C) Neither **L** nor E will have changed.
(D) Both **L** and E will have changed.
(E) It is not possible to say what will happen to **L** and E.

Problem 10:



The S-shaped wire shown above has a mass M, and the radius of curvature of each half is R. The moment of inertia about an axis through A and perpendicular to the plane of the paper is

(A) $(1/2)MR^2$
(B) $(3/4)MR^2$
(C) MR^2
(D) $(3/2)MR^2$
(E) $2MR^2$