MECHANICS

1. A chain of weight w hangs between hooks located at the same height on opposite walls of a room. At the hooks the chain makes an angle θ with the horizontal. What is the tension in the chain at its lowest point?

   a) $w \cos \theta$

   b) $w \cot \theta$

   c) $w \tan \theta$

   d) $\frac{w \cot \theta}{2}$

2. A uniform ladder 35 ft. long rests against a frictionless vertical wall with its lower end 21 ft. from the wall. The ladder weighs 80 pounds. The coefficient of static friction between the foot of the ladder and the ground is 0.4. A man weighing 150 lbs. starts up the ladder. How far up the ladder can he climb before it starts to slip?

   a) 13 ft.

   b) 15 ft.

   c) 17 ft.

   d) 19 ft.

3. A stone is thrown horizontally from the top of a hill 144 ft. above level ground and it is observed to strike the ground at an angle of 45°. With what speed was it thrown?

   a) 64 ft/sec

   b) 72 Ft/sec

   c) 96 ft/sec

   d) 128 ft/sec

4. A ball which was at rest on the floor is hit elastically by a particle which was flying parallel to the floor towards the center of the ball with velocity v. The ball rolls on the floor without slipping. The radius of the ball is r, its mass is M, and its moment of inertia with respect to any line passing through its center is I. The mass of the particle is m. What is the velocity of the ball after the collision?

   a) $\frac{mv}{M + I/r^2}$

   b) $\frac{2\,mv}{m + M + I/r^2}$

c) $\dfrac{2mv}{m + M + 2I/r^2}$

d) $\dfrac{2mv}{M + I/r^2}$

5. If a rubber ball bounced back up to almost the height from which it was dropped, its coefficient of restitution would be nearly

a) unity

b) zero

c) infinity

d) none of these

6. A thin cylindrical shell rolls without slipping down a plane which is inclined at an angle α with respect to the horizontal. The acceleration of the shell along the inclined plane is:

a) $1/3\ g \sin\alpha$

b) $1/2\ g \sin\alpha$

c) $2/3\ g \sin\alpha$

d) $g \sin\alpha$

7. It is desired to find the moment of inertia of a metal disc. A series of measurements is performed and it is found

$p = 10 \pm .2$ gm/cc

$R = 10.0 \pm .1$ cm

$d = 1.0 \pm .03$ cm

where p is the density, R the radius, d = thickness. The value for the moment of inertia and its "probable" error is

a) $3.14 \times 10^5\ (1 \pm .04)$ gm cm^2

b) $1.57 \times 10^5\ (1 \pm .04)$ gm cm^2

c) $1.57 \times 10^5\ (1 \pm .06)$ gm cm^2

d) $3.14 \times 10^5\ (1 \pm .09)$ gm cm^2

The planets move through the sky

a) in circular orbits

b) in elliptical orbits

c) more or less along the ecliptic

d) in exactly the same way as the moon

Ocean tides are caused by

a) the gravitational pull of the moon

b) that of the sun

c) by centrifugal forces

d) a combination of all three

0. A time independent gravitational field is:

a) equivalent to an accelerated frame in a region sufficiently small insofar as local observations are concerned.

b) is equivalent to an accelerated frame without further restrictions.

c) is not equivalent to an accelerated frame for optical measurements.

d) is not equivalent to an accelerated frame for high energy measurements.

1. What is the minimum amount of work that must be done against the earth's gravitational field to move a mass m at rest on the surface of the earth to a point one light year away? R is the radius of the earth, G the universal gravitational constant, g the acceleration caused by gravitational forces at the surface of the earth, and c the velocity of light.

a) m^2 G/R

b) m G R

c) m g R

d) m c^2

12. The period of a satellite going around the earth in a circular orbit

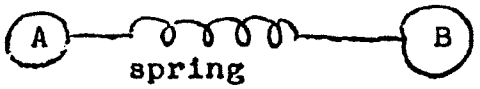
a) is proportional to the cube root of the mass of the earth.

b) depends on the mass of the satellite.

c) is proportional to the three halves power of the distance from the center of the earth.

d) is directly proportional to the universal gravitational constant.

13. At what frequency will this system resonate?



M_A = 2 kg

M_B = 1 kg

Spring Constant = 5 Newtons/meter

a) w = 2.74 radians/sec.

b) w = 1.58 radians/sec

c) w = 3.14 radians/sec

d) w = 2.24 radians/sec

14. The equation

$$m\frac{d^2x}{dt^2} + r\frac{dx}{dt} + kx = F \sin wt$$

describes

a) simple harmonic motion

b) forced harmonic motion

c) diffusion

d) transient behavior of a mass m set in oscillation

15. A cylindrical buoy 2.5 meters high and 800 cm^2 in cross sectional area sinks in sea water until only 1/4 of its volume projects above the surface of the water. The buoy is forced down 30 cm further and then released. The period of the resulting motion is approximately

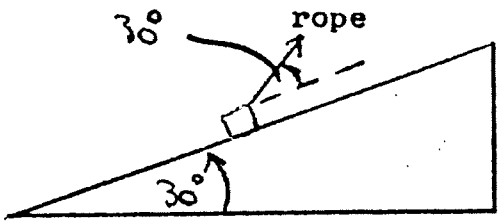
a) 3 sec

b) 30 sec

c) 70 sec

d) 100 sec

16. A block weighing 100 lbs. is held on a frictionless incline by a rope as shown in the diagram.



the tension in the rope is:

a) 58 lbs.

b) 44 lbs.

c) 25 lbs.

d) 100 lbs.

17. A boy sits on a turntable which is rotating with an angular velocity of 60 revolutions per minute. He is hold at arm's length two bricks. Suddenly he releases the bricks. Which of the following best describes the motion of the boy soon after he drops the bricks?

a) His angular velocity remains the same as it was.

b) His angular velocity decreases.

c) His angular velocity increases.

d) His angular velocity cannot be determined without additional information.

18. When a particle moves in a central potential:

a) Total energy is conserved but the angular momentum is not.

b) Both total energy and angular momentum are conserved.

c) The impact parameter is a constant of motion.

d) The particle can have only an elliptic orbit.

19. A bullet of mass m and velocity v hits a hoop of mass M and radius R tangent to the hoop, and continues in the same direction with velocity v/2. The final angular velocity of the hoop is _____?_____, if the hoop is initially at rest in free space.

a) $\frac{m}{MR} \quad \frac{v}{2} \quad \left(1 - \frac{m}{M}\right)$

b) $\frac{m}{MR} \cdot \frac{v}{2}$

c) $\frac{m}{MR} \quad \frac{v}{2} \quad \left(1 - \sqrt{\frac{m}{M}}\right)$

d) $\sqrt{\frac{m}{M}} \quad \frac{1}{R} \quad \frac{v}{2}$

20. For large amplitudes, the period of a mathematical pendulum of length L under the influence of the gravitational acceleration g is:

a) larger than $2\pi \sqrt{L/g}$

b) equal to $2\pi \sqrt{L/g}$

c) smaller than $2\pi \sqrt{L/g}$

d) dependent on the mass of the pendulum.

21. The velocity of propagation of transverse waves in a string stretched with tension T and mass per unit length μ is:

a) $\frac{\mu}{T}$

b) $\sqrt{\frac{T}{\mu}}$

c) $\frac{T}{\mu}$

d) $\sqrt{\frac{\mu}{T}}$

22. An astronaut in an orbiting satellite undergoes a feeling of weightlessness because:

a) He is not under the influence of the earth's gravity.

b) He is in a state of free fall.

c) There is a force on him equal and opposite to the earth's gravitational force.

d) None of the above.

23. A long hole is drilled through the center of the earth from the North Pole to the South Pole. An object is released from rest into the hole from the surface of the earth at one end. Assume the earth is spherical.

a) The object will just reach the center of the earth and turn around.

b) The object will fall out the other end of the hole.

c) The object will just reach the other end of the hole and turn around.

d) None of the above.

24. For the same pressure gradient, water flows through a tube faster than honey because it is:

a) less dense.

b) less elastic.

c) less volatile.

d) less viscous.

25. It is desired to measure the moment of inertia of a metal disc. Its radius and mass were measured,

$$M = 100 \pm 2 \text{ gm}$$

$$R = 5.0 \pm 0.15 \text{ cm}$$

where the probable errors are given. What is the probable percentage error in the calculated moment of inertia?)The root-mean-square error is desired.)

a) 5%

b) 10%

c) 8%

d) 6%

26. A box containing water slides freely down a long, frictionless inclined plane. The surface of the water is:

a) Parallel to the inclined plane.

b) At an angle between the horizontal surface and the inclined plane.

c) Parallel to the horizontal surface.

d) At an angle greater than the angle of inclination of the plane.

27. A horizontal cylinder is rolling down a plane inclined at angle a to the horizontal (i.e., a = 0 for a level plane). If g is the usual gravitational acceleration of a body in free fall, the actual acceleration of the axis of the cylinder is:

a) less than g sin a

b) exactly g sin a

c) exactly g

d) greater than g sin a

28. A glass is filled to the brim with water, and has an ice cube floating in it. As the ice cube melts

a) the water in the glass will overflow.

b) the water level in the glass will become lower.

c) the water in the glass may or may not overflow, depending on the rate at which the ice cube melts.

d) the water will remain at the same level.

29. If a mass m is subjected to a restoring force - Kx and no other force, it will undergo simple harmonic oscillation with a:

a) frequency K/m

b) superposition of frequencies given by $n(K/m)^{1/2}$, where $n = 0,1,2,\ldots$

c) superposition of frequencies given by nK/m, where $n = 0,1,2,\ldots$

d) frequency $(K/m)^{1/2}$

30. An empty wagon of mass M is started with velocity V_o during a rainstorm on a windless day. If the wagon collects water at a rate of r pounds per second, the velocity after a time t is:

a) $V_o \left(1 + \frac{rt}{M}\right)^{-1}$

b) $V_o \left(1 + \frac{rt}{M}\right)^{-1/2}$

c) V_o

d) $V_o e^{-rt/M}$

11. Does the period of a planet orbiting around the sun depend on

a) its mass,

b) its distance from the sun,

c) both

d) any other property of the planet.

12. Lagrange's equation for a mechanical system with n degrees of freedom are:

a) $\frac{\partial L}{\partial q_i} = \frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right)$, $i = 1, 2, \ldots, n$

b) $\frac{\partial L}{\partial \dot{q}_i} = \frac{d}{dt}\left(\frac{\partial L}{\partial q_i}\right)$, $i = 1, 2, \ldots, n$

c) $\frac{\partial L}{\partial \dot{q}_i} = \partial_{\delta q_i}\left(\frac{\partial L}{\partial t}\right)$, $i = 1, 2, \ldots, n$

d) $\frac{\partial L}{\partial q_i} = \partial_{\partial \dot{q}_i}\left(\frac{\partial L}{\partial t}\right)$, $i = 1, 2, \ldots, n$

13. Sound waves in a solid

a) are only longitudinal,

b) may be either transverse or longitudinal,

c) are only transverse,

d) are only of the shear type.

14. An amateur rifleman proposes to find the velocity of a bullet by shooting it into a 2" x 4" plank that is held at the top by a hinge and observing the amount of the swing. To calculate the velocity of the bullet from the velocity given to the plank he should use

a) the law of conservation of energy,

b) the law of conservation of linear momentum,

c) the law of conservation of angular momentum,

d) any one or all are equally valid and easy to apply.

35. A simple pendulum has a period of 1.00 second when suspended from a mount at rest on the surface of the earth. ($g=32.0$ ft/sec^2). What will be its period in a system which is moving with a horizontal linear speed of 32.0 ft/sec. and a horizontal linear acceleration of 24.0 ft/sec.^{2} ?

a) 1.32 seconds,
b) 0.71 seconds,
c) 1.00 seconds,
d) 0.89 seconds.

36. In a system composed of two spherically symmetric masses interacting through gravitational attraction only, the angular momenta associated with the internal rotations of both masses are ___?___ conserved.

a) always,
b) sometimes,
c) never,
d) nearly.

37. A billiard ball of radius R and mass M is given a horizontal impulse upon being struck at a point R/3 above table surface. The ratio of the initial velocity v to the product of the initial angular velocity w and the radius, (v/wR) is

a) 3/5,
b) 21/5,
c) 1,
d) depends upon the coefficient of friction.

38. In the free fall of a body, if the mass of the body is increased by a factor of two, the time of fall changes by:

a) 1/2,
b) 1/2,
c) 2,
d) remains the same.

39. Given a simple pendulum that has a small spherical bob. A 30kg sphere of radius 10 cm is brought up just next to the bob; it is noted that the bob moves toward the mass a distance of 4800 A. The period of the pendulum is 10 sec. Calculate G, the constant of gravitation.

a) $6.4 \times 10^{-8} \ \frac{\text{dyne cm}^2}{\text{gm}^2}$

b) $6.8 \times 10^{-9} \ \frac{\text{dyne cm}^2}{\text{gm}^2}$

c) $6.8 \times 10^{-12} \ \frac{\text{dyne cm}^2}{\text{gm}^2}$

d) $7.5 \times 10^{-8} \ \frac{\text{dyne cm}^2}{\text{gm}^2}$

40. A cylindrical shell of mass M and radius R rotating with angular velocity W about its axis, and falling with velocity V, rebounds elastically from a horizontal surface having a large coefficient of friction. What angle will the path of the center of mass of the shell make with the vertical direction just after the rebound?

a) arccos (RW/2V),

b) arctan (RW/2V),

c) arctan (RW/V),

d) none of the above.

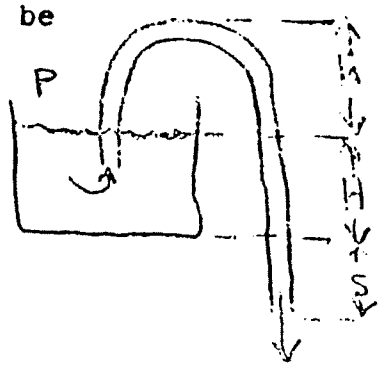
41. Water is siphoned, as shown from a container through a tube which has an area much smaller than that of the container. Siphoning will no longer be possible when h is made greater than

a) $\frac{P}{\rho g} - H - S$

b) $\frac{P}{\rho g}$

c) $H + S$

d) S



ρ is the density of the liquid

42. A cork is attached to the bottom of a bucket by a spring. The bucket is filled with water, and sits on the floor of an elevator. If the elevator suddenly accelerated upward, the cork will

a) Move closer to the bottom of the bucket

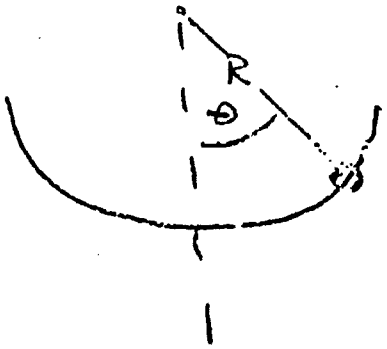
b) Move away from the bottom of the bucket

c) Stay at the same distance from the bottom of the bucket

d) move up or down depending on whether the acceleration is less than or greater than 1 g.

43. Consider a bead of mass m constrained to move on the frictionless rim of a vertical hoop of radius R.

The expression $[m R^2 \dot{\theta}^2 - mgR (1 - \cos \theta)]$ is



a) the kinetic energy

b) the Lagrangian

c) the Hamiltonian

d) the total energy

of the bead.

44. An incompressible fluid is pumped slowly through a pipe with a constriction. Is the pressure on the wall in the constriction

a) lower than

b) higher than

c) or equal to

that in the adjacent straight section, or

d) depends on the shape of the constriction

45. What is the maximate ratio of the vertical speed needed for a satellite to escape the earth's gravitational pull to the speed needed just to maintain a satellite in a close circular orbit?

a) $\sqrt{4\pi}$ b) $\sqrt{2}$

c) 2 d) $\frac{4}{3}$