

Instructions:

- 1) Wait for oral instructions before starting the test.
- 2) Don't forget to write and encode your name and number on the answer sheet.

ALSO WRITE AND ENCODE "211NNN", WHERE NNN IS YOUR SEAT NUMBER, IN THE "SPECIAL CODES".

- 3) Only one of the five alternative answers is the correct answer to the question.
- 4) No calculators or other aids permitted.
- 5) Good Luck!

MAKE SURE YOU HAVE ALL 60 QUESTIONS ON THE QUESTION PAPER

Some of these formulae might help you.

$$v = v_0 + at$$

$$w = mg$$

$$W = (F \cos \theta)s$$

$$F_S = -kx$$

$$p = mv$$

$$a_t = r\alpha$$

$$F = Gm_1m_2/r^2$$

$$\sum \tau = I\alpha$$

$$F_{SHM} \propto -x$$

$$f = 1/T$$

$$\cos 45^\circ = \sin 45^\circ = 1/\sqrt{2}$$

$$\sin \theta = o/h$$

$$x = v_0t + \frac{1}{2}at^2$$

$$f_s \leq \mu_s n$$

$$KE = \frac{1}{2}mv^2$$

$$PE_S = \frac{1}{2}kx^2$$

$$\text{Impulse} = F\Delta t = \Delta p$$

$$a_c = v^2/r = r\omega^2$$

$$\tau = Fd$$

$$L = I\omega$$

$$T_s = 2\pi\sqrt{m/k}$$

$$x = A \cos(2\pi ft)$$

$$\tan 45^\circ = 1$$

$$\cos \theta = a/h$$

$$\sum F = ma$$

$$f_k = \mu_k n$$

$$W_{net} = KE_f - KE_i$$

$$PE_g = mgh$$

$$v_t = r\omega$$

$$F_c = mv^2/r$$

$$I = \sum mr^2$$

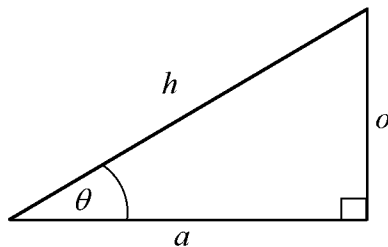
$$KE_r = \frac{1}{2}I\omega^2$$

$$T_p = 2\pi\sqrt{L/g}$$

$$v = \lambda f$$

$$\sin 30^\circ = \cos 60^\circ = 1/2$$

$$\tan \theta = o/a$$



1) A vector \vec{A} has components A_x and A_y and magnitude A . A vector of the same size but in the opposite direction

- a) can be represented by $-\vec{A}$
- b) has components $-A_x$ and $-A_y$
- c) has magnitude A
- d) has magnitude $\sqrt{A_x^2 + A_y^2}$
- e) all of the above

2) An object, starting (at $t = 0$) from rest at $x = 0$, moves to $x = a$ where it is again at rest after a time t_a . Its average velocity for this period

- a) cannot be expressed in terms of the above quantities
- b) is zero
- c) is less than its maximum velocity while in motion
- d) is the tangent to the curve at $t = t_a$ on a position time graph
- e) is the normal to the curve at $t = t_a$ on a position time graph

3) At $t = 0$ an object is at x_0 . At $t = t_1$ the object is at x_1 . On a graph of position versus time, the instantaneous speed of the object at time t is given by

- a) the normal to the curve at t
- b) the tangent to the curve at t
- c) the straight line joining $x = x_0, t = 0$ and $x = x_1, t = t_1$
- d) the area under the curve between $t = 0$ and $t = t_1$
- e) both (c) and (d)

4) A ball is thrown vertically upwards with speed v_0 , rises to some maximum height and then falls down to the ground. Its acceleration while it is in the air (ignoring air resistance)

- a) is a maximum just before it hits the ground
- b) is a maximum when it is at its maximum height
- c) is a minimum when it is at its maximum height
- d) is constant
- e) depends on the mass of the ball

5) CASE I: A ball is thrown vertically *upwards* with speed v_0 from the top of a building and eventually hits the ground at the base of the building. CASE II A ball is thrown vertically *downwards* with speed v_0 from the top of the same building. The speed of the ball as it hits the ground

- a) is the same for CASE I and CASE II
 - b) is greater for CASE I than CASE II
 - c) is less for CASE I than CASE II
 - d) either (b) or (c) depending on the height of the building
 - e) not enough information has been given
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6) The equation $x = \frac{1}{2}at^2$, for the position of an object at time t , is valid

- a) for an acceleration a that is varying with time
- b) only for an acceleration a that is positive
- c) only for an initial speed that is zero
- d) only for an initial speed that is positive
- e) only for an initial speed that is negative

7) A bullet is fired with speed v_0 horizontally at a height of six feet across the Utah salt flats. Its speed when it hits the ground (neglecting air resistance)

- a) is equal to v_0
- b) is greater than v_0
- c) is less than v_0
- d) has a vertical component of zero
- e) both (b) and (d)

8) If an object is accelerating but its speed does not change

- a) this is a physical impossibility
- b) the acceleration is in a direction perpendicular to its velocity
- c) it is travelling in a circle
- d) both (b) and (c)
- e) it is stationary

BOTH ALLOWED

9) A projectile is launched with initial speed v_0 , from ground level, at an angle θ with respect to the positive x -direction (which is horizontal; the y -axis is vertically upwards). The projectile lands a certain horizontal distance (the range) from the launch position. If θ is less than 45°

- a) the range is greater than for $\theta = 45^\circ$
- b) the range does not depend on v_0
- c) there is another angle θ with the same range
- d) the projectile will always land with a speed greater than v_0
- e) the projectile will land with a speed that depends on θ

10) You are standing in the aisle of a bus travelling at 30 miles per hour. You hold a book in front of you and above the floor. You let go of the book.

Which TWO laws of motion best explain the fact that an observer on the sidewalk sees the book land on the floor by your feet?

- a) Newton's first and second laws of motion
- b) Newton's first and third laws of motion
- c) Newton's second and third laws of motion
- d) None of the above
- e) Not enough information has been given

11) A point object can be in equilibrium only if

- a) $\sum F_x = 0$ b) $\sum F_y = 0$ c) $\sum F_z = 0$
d) Any two of a), b), and c)
e) All of a), b), and c)
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12) A mass is placed on a slope. Friction is enough to keep the mass at rest. The component of the net force

- a) parallel to the slope is zero
b) perpendicular to the slope is zero
c) both (a) and (b)
d) in both the horizontal and vertical directions is zero
e) all of the above
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13) Same answers as above for the case where friction is insufficient to keep the mass at rest

(b)

14) A point mass M_0 is suspended from the ceiling by a massless rope. In a free body diagram of the point mass M_0 , the upward force is numerically the same as

- a) zero
b) The tension at the top of the rope
c) The tension at the middle of the rope
d) The tension at the bottom of the rope
e) (b) and (c) and (d) because the tensions are the same
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15) A mass M is placed at the top of a ramp. There is a static coefficient of friction $\mu_s = 1$ between the mass and the ramp. The angle of the ramp (with respect to the horizontal) is gradually increased from zero, until the mass just begins to slide. The angle at which this occurs

- a) depends on M
b) is 30°
c) is 45°
d) is 60°
e) depends on the local value of g , the acceleration due to gravity
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16) At $t = 0$ a mass M is moving with velocity v_0 on a horizontal table on the Earth. There is a kinetic coefficient of friction μ , between the mass and the table, that results in a retarding force. The time taken for the mass to come to rest

- a) would be longer on a planet more massive than the Earth but with the same radius
b) would be shorter on a planet less massive than the Earth but with the same radius
c) both a) and b)
d) would be the same on any planet
e) would be shorter on a planet more massive than the Earth but with the same radius

17) A mass m has a speed v resulting in a kinetic energy KE_1 . If the mass were one half the value, and the speed were doubled, the kinetic energy would be $KE_2 = A \times KE_1$. The value of A is

- a) 4 **b) 2** c) 1 d) 1/2 e) 1/4
-

18) Which of the following does not have the units of energy?

- a) force \times distance
b) mass \times distance \times acceleration
c) mass \times time² / distance
d) mass \times velocity²
e) mass \times distance \times velocity / time
-

19) Two springs are compressed the same amount over the same period of time. If spring #1 has twice the spring constant of spring #2, then the work done on #1 is _ that done on #2, and the average power needed for #1 is _ that for #2.

- a) half, half
b) the same as, half
c) the same as, the same as
d) the same as, twice
e) twice, twice
-

20) A book is being accelerated across a table in the presence of friction. A free body diagram of the book would require the inclusion of how many forces?

- a) 1
b) 2
c) 3
d) 4
e) 6
-

21) A book of mass m rests on a horizontal table. There is a normal force n upwards due to the force of the table atoms on the book atoms. If an external force F_h is applied horizontally to accelerate the book across the table, the work done BY THE NORMAL FORCE n after the book has traveled a distance d

- a) depends on F_h
b) depends on d
c) depends on n
d) all of the above
e) is zero

22) An object is resting on the floor. You pick it up and place it on a table three feet high.

- a) You have done negative work on the book
- b) You have done zero work on the book
- c) Gravity has done negative work on the book
- d) Gravity has done zero work on the book
- e) Gravity has done positive work on the book

23) At $t = 0$ an object is released from the top of a frictionless ramp of height H above the ground. Also at $t = 0$ another object is dropped vertically from a height H above the ground.

- a) the dropped object reaches the ground first
- b) both objects have the same speed when they reach the ground
- c) the normal force acting on the ramp object does no work
- d) gravity does the same amount of work in both cases, even though one object travels a greater distance than the other
- e) all of the above

24) If the kinetic energy of an object were doubled, the magnitude of its momentum would increase by a factor

- a) 4
- b) 2
- c) 1
- d) 1/2
- e) none of the above

25) The conservation of momentum may be applied to an isolated system if

- a) kinetic energy is conserved
- b) kinetic energy is not conserved
- c) there are internal forces acting
- d) All of the above
- e) None of the above

26) When a ball bounces elastically from the surface of the earth

- a) there is exactly zero change in the momentum of the ball
- b) there is exactly zero change in the momentum of the earth
- c) the ball's momentum change $|\Delta\vec{p}_B|$ is nearly twice the ball's initial momentum $|\vec{p}_B|$
- d) the earth's momentum change $|\Delta\vec{p}_E|$ is nearly twice the ball's initial momentum $|\vec{p}_B|$
- e) both c) and d)

27) A very light table-tennis (ping-pong) ball is held vertically above, and in contact with, a heavy ball. The combination is dropped from a height y onto the floor (i.e. the very, very massive ball we call the Earth). Assuming that all collisions are elastic, the ping-pong ball reaches a maximum height

- a) slightly less than y
- b) several times y
- c) exactly y
- d) slightly less than $y/2$
- e) the same as the heavy ball

28) It is possible for two non-stationary objects to have a total momentum of zero if

- a) they are traveling in the same direction
- b) they are traveling in opposite directions
- c) they are travelling at right angles to each other
- d) it is never possible if they have the same mass
- e) it is never possible if they have different masses

29) A mass m_1 has a speed v_1 and a mass m_2 has a speed v_2 . The two masses collide ELASTICALLY after which they have speeds v'_1 and v'_2 . Which of the following is (are) true

- a) $\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = \frac{1}{2}m_1v_1'^2 + \frac{1}{2}m_2v_2'^2$
- b) $v_1 + v'_1 = v_2 + v'_2$
- c) $m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$
- d) Only b) and c)
- e) All a), b), c)

30) The same as above, but for a perfectly inelastic collision (c)

31) The same as above, but for the general type of inelastic collision (c)

32) An object is at the edge of a disk that is rotating with constant angular velocity X radians per second. Another object halfway between the edge and the center has an angular velocity

- a) $2X$
- b) $X/2$
- c) X
- d) $X/(2\pi)$
- e) not enough information has been given

33) If an object is moving in a circle of constant radius under the influence of a force of constant magnitude, which of the following must be true

- a) its speed must be varying with time
- b) its velocity must be constant in time
- c) its acceleration must be zero at all times
- d) the force must be perpendicular to its velocity at all times
- e) none of the above

34) Two planets have the same acceleration due to gravity at their surface. If planet #1 is twice the radius of planet #2, then planet #1 has _ the mass of planet #2

- a) 4 b) 2 c) 1 d) 1/2 e) 1/4
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35) A car with speed v travels safely in a circle of radius R . The road is banked at some angle θ to the horizontal. The road exerts a normal force n on the car.

- a) The centripetal force can be provided by a vertical component of n
b) The centripetal force can be provided by a horizontal component of n
c) There MUST be a component of frictional force between the tires and the road, directed towards the center of the circle
d) There MUST be a component of frictional force between the tires and the road, directed away from the center of the circle
e) Not enough information has been given
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36) As above, but for an unbanked (horizontal) road. (c)

37) A ladder is leaning against a wall. There is friction between the wall and the top of the ladder, but there is NO friction between the ground and the bottom of the ladder. The ladder starts to slip. It can be made stable by placing a cannon ball

- a) midway up the ladder
b) on the upper half of the ladder
c) on the lower half of the ladder
d) any of a), b), c) depending on the mass of the cannon ball
e) the ladder cannot be made stable with a cannon ball
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38) Two forces \vec{F}_1 and \vec{F}_2 act on a finite sized object. The forces may act at any points you choose. If $\vec{F}_1 = -2\vec{F}_2$ the following cases are NOT possible

- a) a net translational force but no net torque
b) a net translational force and a net torque
c) no net translational force but a net torque
d) all the above are not possible
e) not enough information has been given
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39) A worker P can exert a maximum force F when lifting an object. Another worker Q can exert a maximum force HALF as large. They wish to lift a long heavy plank of mass $m = 3F/g$ whose center of gravity (c of g) is at the geometric center of the plank. P and Q should lift as follows:

- a) one at each end
b) P at one end and Q at the c of g
c) P at one end and Q halfway between the c of g and the other end
d) each of them halfway between the c of g and each end
e) the plank is too heavy for them to lift

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- 40) The position of the center of gravity of an object measured on the earth
- a) can lie outside the material of the object
 - b) is in the same place if the object is taken to the moon
 - c) does not change if the object is turned upside down
 - d) all the above
 - e) none of the above

Begin New Stuff

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- 41) A translational force can produce an impulse given by the usual expression. The rotational equivalent is
- a) $\tau = Fd$ b) $L = I\omega$ c) $\tau = I\alpha$ d) $\Delta L = \tau\Delta t$ e) $KE = \frac{1}{2}I\omega^2$

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- 42) (and the next question). Two point masses, both with $m = 1\text{kg}$ are at the end of a light rod of length $L = 1\text{m}$. There is an axle at the center of the rod, and perpendicular to the rod. It is desired to make the rod rotate about the axle with an angular acceleration of $\alpha = 1 \text{ radians/s}^2$. The required torque τ is (in m.N)
- a) 4 b) 2 c) 1 d) 1/2 e) 1/4

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- 43) As above but for an axle through one of the masses, and perpendicular to the rod. Same answers as above.

(c)

44) (and the next 4 questions). A thin-walled hollow cylinder of length L , radius R and mass M is released from rest at the top of an incline a vertical distance h above the ground. At some later time it is rolling with translational speed v down the slope.

Its angular velocity about an axis through the center of the cylinder (and parallel to its sides) is then

- a) v^2/R b) vR c) v^2R d) v e) v/R

45) Its moment of inertia about this axis is

- a) ML^2/R b) ML^2 c) MR^2 d) MLR e) MR^2/L

46) The ratio L/p of its angular momentum L to its linear (translational) momentum p is

- a) 1 b) 2 c) R/L d) L e) R

47) The ratio $KE(Rot)/KE(Trans)$ of its rotational kinetic energy to its translational kinetic energy is (same choices as previous question)

(a)

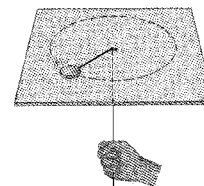
48) At the bottom of the slope it has the same translational speed as an object dropped a height

- a) $h/2$ b) $h/\sqrt{2}$ c) h d) $\sqrt{2}h$ e) $2h$

49) (and the next 4 questions) In the figure the mass m (attached to a massless string) is traveling with speed v_1 in a circle of radius r_1 .

The angular momentum of the mass is

- a) mv^2/r b) $\frac{1}{2}mv/r$ c) mv/r
d) mvr e) mv^2r



50) The string is then pulled down until the mass is traveling in a smaller circle of radius r_2 . The angular momentum of the mass (about the center of the circle) is conserved during this process and

- a) there are no forces or torques acting on the mass
b) there are forces but no torques acting on the mass
c) there are torques but no forces
d) there are both forces and torques acting on the mass
e) angular momentum is not conserved

51) The new speed v_2 of the mass is

- a) v_1 b) $v_1 \frac{r_1}{r_2}$ c) $2v_1 \frac{r_2}{r_1}$ d) $\frac{1}{2}v_1 \left(\frac{r_2}{r_1}\right)^2$ e) 0

52) For the new orbit, the tension in the string (which provides the central force) is _____ it was before.

- a) less than
b) the same as
c) greater than
d) either a) or c) depending on m
e) not enough information has been given

53) The work done by the tension is W , in causing the orbit to get smaller. The change in the kinetic energy of the mass is ΔKE .

- a) W is positive and ΔKE is negative
b) W is positive and ΔKE is positive
c) W is zero and ΔKE is zero
d) W is positive and ΔKE is zero
e) W is zero and ΔKE is positive

54) An object is undergoing SHM. When its displacement is a maximum

- a) its speed is a maximum
- b) its acceleration is a maximum
- c) its acceleration is zero
- d) both a) and b)
- e) both a) and c)

55) An object is undergoing SHM. When its kinetic energy is equal to its potential energy

- a) its speed is a maximum
- b) its acceleration is a maximum
- c) its displacement is zero
- d) all of the above
- e) none of the above

56) (and the next question) A horizontal spring is fixed to a wall at one end. At the other end a mass m executes horizontal SHM on a frictionless surface about the natural length (ie unstretched or uncompressed) of the spring. The spring is then hung from the ceiling and the mass executes vertical SHM in the earth's gravitational field. This SHM is about

- a) A position at the natural length of the spring
- b) A position above the natural length of the spring that depends on m
- c) A position above the natural length of the spring that does not depend on m
- d) A position below the natural length of the spring that depends on m
- e) A position below the natural length of the spring that does not on m

57) If the period of horizontal SHM was 6 seconds, the new period is (in seconds)

- a) 3
- b) 9
- c) I need to know the value of the mass
- d) I need to know the value of the spring constant
- e) none of the above

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- 58) Two men (!) sit side by side on a swing. For small amplitudes, the period of the swing
- a) depends on the amplitude of the swinging motion
 - b) is longer than if there was only one man on the swing
 - c) is shorter than if there was only one man on the swing
 - d) is the same as if there was only one man on the swing
 - e) both a) and d)

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- 59) An harmonic wave is characterized by its wavelength λ , frequency f , speed v , and amplitude A . Which of the following are true
- a) it travels with wavelength given by $\lambda = v/f$
 - b) it transports energy from one place to another
 - c) the displacement at any point in space exhibits SHM
 - d) all of the above
 - e) none of the above

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- 60) An harmonic sound wave is characterized by its wavelength λ , frequency f , speed v , and amplitude A . A sound wave can pass from air into a solid object (such as a brick wall) and out again. In such a case which of the following has the same value in air and the solid object?
- a) f
 - b) λ
 - c) v
 - d) A
 - e) all the above

————— THE END —————