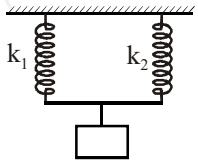
SECTION -2
PART-A
[SINGLE CORRECT CHOICE TYPE]

Q.1 to Q.3 has four choices (A), (B), (C), (D) out of which **ONLY ONE** is correct. **[3 Marks]**

Q.1 Two vertically arranged springs of equal length support a horizontally suspended weightless rod. Spring constant $k_1 = 30$ N/m and $k_2 = 50$ N/m, the distance between them is d = 1 m. At what distance from a spring with stiffness k_1 should we hang a mass so that the rod will be in a horizontal position (Figure).



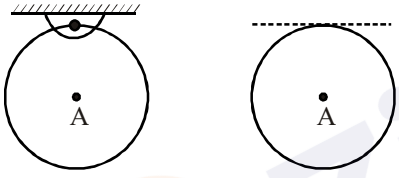
(A) 0.375 m (B) 0.625 m (C) 0.5 m (D) 0.75 m

Q.2 A body Heated up to $t_1 = 100°C$ was lowered into the vessel with water. The water temperature rose from $t_2 = 20°C$ up to $t_3 = 30°C$. What will be the temperature of the water if another identical body, heated to $t_4 = 80°C$ is also dipped in it after that? The heat capacity of the vessel and heat losses negligible.
(A) 280/9°C (B) 40°C (C) 145/4°C (D) 320/9°C

Q.3 How many points are there on a sphere rolling with a uniform velocity v which has a velocity equal to 2v?
(A) 1
(B) 2
(C) infinite
(D) no point on the sphere has a velocity 2v

Q.4 to Q.6 has four choices (A), (B), (C), (D) out of which **ONLY ONE** is correct. **[4 Marks]**

Q.4 A uniform disk is free to rotate about a horizontal axis passing through a point on its periphery. We have two choice of axes (i) perpendicular to the plane of the disc and (ii) within the plane of the disc as shown in the figure. The disc is rotated so that A comes to the same level as the point of suspension and released. In which case is the angular velocity of the disc larger by the time A comes to the lowest position ?



(A) case (i)
(B) case (ii)
(C) Same in both the cases
(D) Depends on the mass and the radius of the disc

Q.5 A solid cylinder and a solid sphere have equal masses. Both roll without slipping on a horizontal surface. If their kinetic energies are the same, then

(A) the translational speed of the cylinder is greater than that of the sphere.
(B) the translational speed of the cylinder is less than that of the sphere.
(C) the translational speeds of the two objects are the same.
(D) (A), (B) or (C) could be correct depending on the radii of the objects.

Q.6 The co-efficient of thermal expansion of a rod is temperature dependent and is given by the formula $\alpha = aT$, where a is a constant and T in ºC. If the length of the rod is ℓ at temperature 0ºC, then the temperature at which the length will be 2ℓ is :

(A) $\sqrt{\frac{\ell n2}{a}}$ (B) $\sqrt{\frac{\ell n4}{a}}$ (C) $\sqrt{\frac{2\ell}{a}}$ (D) $\sqrt{\frac{\ell}{a}}$

[PARAGRAPH TYPE]

Q.7 to Q.8 has four choices (A), (B), (C), (D) out of which **ONLY ONE** is correct. **[2 Marks]**

Paragraph for question nos. 7 to 8

A uniform rod of length L rests on a frictionless horizontal surface. The rod pivots about a fixed frictionless vertical axis at one end. The rod is initially at rest. A bullet travelling parallel to the horizontal surface and perpendicular to the rod with speed v strikes the rod at its center and becomes embedded in it. The mass of the bullet is one-fourth the mass of the rod.

Q.7 What is the final angular speed of the rod?

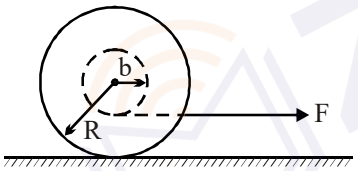
(A) $\frac{6v}{13L}$ (B) $\frac{6v}{17L}$ (C) $\frac{12v}{13L}$ (D) $\frac{6v}{19L}$

Q.8 The correct statement about the collision (for the entire system) is
(A) The momentum and angular momentum about the axis is conserved but the mechanical energy has been lost.
(B) The angular momentum about the axis is conserved but the mechanical energy as well as momentum has been lost.
(C) The angular momentum about the axis, momentum, and kinetic energy have all changed.
(D) The angular momentum about the axis, momentum, and kinetic energy have all been conserved.

Q.9 to Q.11 has four choices (A), (B), (C), (D) out of which **ONLY ONE** is correct. **[3 Marks]**

Paragraph for question nos. 9 to 11

A Yo-Yo of mass m has an axle of radius b = R/2 and a spool of radius R . It's moment of inertia about an axis passing through the center of the Yo-Yo can be approximated by $I = (1/2)mR^2$. The Yo-Yo is placed upright on a table and the string is pulled with a horizontal force F to the right as shown in the figure.



Q.9 The string is pulled with a small force. The yo-yo is seen to roll purely. It will
(A) Move to the left and rotate anticlockwise
(B) Move to the left and rotate clockwise

(C) Move to the right and rotate anticlockwise
(D) Move to the right and rotate clockwise

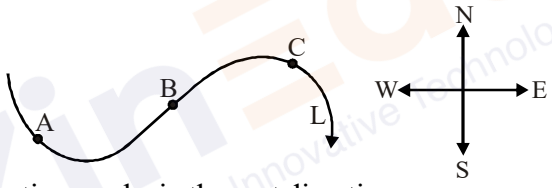
Q.10 In this situation (of pure rolling),
(A) Force F is increasing the translational kinetic energy as well as rotational kinetic energy
(B) Force F is increasing the translational kinetic energy but decreasing rotational kinetic energy
(C) Force F is decreasing the translational kinetic energy but increasing rotational kinetic energy
(D) Force F is decreasing the translational kinetic energy as well as rotational kinetic energy

Q.11 If the force F is such that the yo-yo does not rotate at all but purely translates (μ is coefficient of friction)
(A) It has an acceleration towards the left of magnitude μg
(B) It has an acceleration towards the right of magnitude $\mu g/2$
(C) It has an acceleration towards the right of magnitude $2\mu g$
(D) It has an acceleration towards the right of magnitude μg

[MULTIPLE CORRECT CHOICE TYPE]

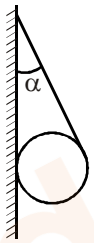
Q.12 to Q.15 has four choices (A), (B), (C), (D) out of which **ONE OR MORE** may be correct. **[4 Marks]**

Q.12 A body is moving with constant tangential acceleration along the trajectory L (Fig.). Comment on the vector of the total acceleration at the points A, B and C. The point B is on a straight trajectory.



(A) At point A the acceleration can be in the east direction
(B) At point B the acceleration can be in the north east direction
(C) At point C the acceleration can be in the south direction
(D) The magnitude of acceleration at A is more than that at B.

Q.13 A cylinder of radius R and mass m is wound to a string and suspended from a vertical wall (figure). The cylinder does not slide on the wall. The coefficient of friction between the wall and the cylinder is μ. Select the correct statement(s) :



(A) The force of friction on the cylinder is upwards
(B) The minimum value of μ required is cosec α.
(C) The tension in the string is greater than the weight
(D) The tension in the string is less than the weight

Q.14 Select the correct statements :
(A) All the points on a rotating wheel have the same acceleration
(B) All the points on a rotating wheel have the same angular acceleration
(C) All the points on a rotating wheel have the same linear velocity
(D) All the points on a rotating wheel have the same angular velocity

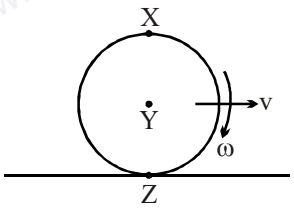
Q.15 A block of ice at –20°C having a mass of 2 kg is added to a 3 kg water at 15°C. Neglecting heat losses and the heat capacity of the container
(A) The final temperature will be 0°C. (B) Ice will partly melt

(C) Water will partially freeze (D) Final temperature will be more than 0°C.

PART–B
[MATRIX TYPE]

Q.1 has **three** statements (A,B,C) given in **Column-I** and **four** statements (P,Q,R,S) given in **Column-II**. Any given statement in **Column-I** can have correct matching with one or more statement(s) given in **Column-II**. Marks given only if all matching are correct.

Q.1 Consider a sphere rolling on a rough ground with constant velocity. Y is the centre of mass of the sphere, X is topmost point and Z is point in contact with the ground.



Column-I		**Column-II**	
(1)	Point X	(P)	has zero acceleration
(2)	Point Y	(Q)	the acceleration is directed towards Y
(3)	Point Z	(R)	has zero velocity
		(S)	has constant velocity

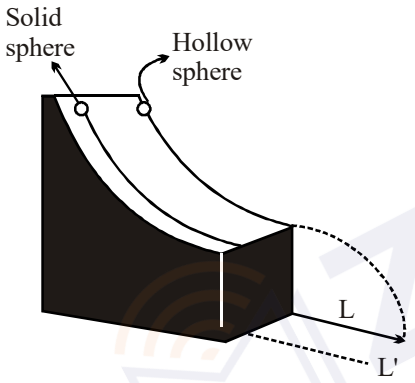
(A) $1 \to Q, 2 \to PS, 3 \to QR$ (B) $1 \to QR, 2 \to PS, 3 \to Q$

(C) $1 \to QR, 2 \to Q, 3 \to PS$ (D) $1 \to Q, 2 \to QR, 3 \to PS$

PART–D
[INTEGER TYPE]

Q.1 to Q.5 are "Integer Type" questions. (The answer to each of the questions **are upto <u>4 digits</u>**)

Q.1 A hollow sphere and solid sphere of the same mass and radius roll down an inclined plane from the same height H without slipping (figure). Each is moving horizontally as it leaves the ramp. When the spheres hit the ground, the range of the hollow sphere is $L = \sqrt{21}$ m. Find the range L' (in m) of the solid sphere.



Q.2 A steel rod (density = 8000 kg/m^3) has a length of 2.0 m. It is bolted at both ends between immobile

supports. Initially there is no tension in the rod, because the rod just fits between the supports. Find the tension (in N) that develops when the rod loses 3600 J of heat. Take specific heat capacity of steel as 450 J/kg°C. coefficient of linear expansion = 10^{-5} /°C. Young's modulus = 2×10^{11} N/m^2.

Q.3 A steel rod of length 1 m and cross section area 1mm^2 is fixed at its end in a vertical plane. When a horizontal force is applied at its end, the end displaces by 12.5 mm. When the same force is used to pull the rod, it will extend by _____mm. Shear modulus for the steel rod is 80×10^9 N/m^2, Young modulus for the rod is 200×10^9 N/m^2.

Q.4 A meterstick is held to a wall by a nail passing through the 60 cm mark (figure). The meterstick is free to swing about this nail, without friction. If the meterstick is released from an initial horizontal position, what force (in N) acts on the nail just after release. Mass of meter stick is 560 gm. ?

Q.5 A 4 kg bomb sliding on a frictionless surface explodes into two 2 kg parts: one travelling with a velocity of 6 m/s due north and another with 10 m/s in direction of 30° north of east. what was the original speed (in m/s) of the bomb?

ANSWER KEY

PART-A
Q.1 B
Q.2 D
Q.3 A
Q.4 B
Q.5 B
Q.6 B
Q.7 D
Q.8 B
Q.9 D
Q.10 B
Q.11 D
Q.12 ABCD
Q.13 ABD
Q.14 BD
Q.15 AB

PART-B
Q.1 (A) Q
(B) P,S
(C) Q,R

PART-D
Q.1 0005
Q.2 1000
Q.3 0005
Q.4 0005
Q.5 0007