विध्न विचारत भीरु जन, नहीं आरम्भे काम,
विपति देख छोड़े तुरंत मध्यम मन कर श्याम।
पुरुष सिंह संकल्प कर, सहते विपति अनेक,
'बना' न छोड़े ध्येय को, रघुबर राखे टेक।।

रचितः मानव धर्म प्रणेता
सद्गुरु श्री रणछोड़दासजी महाराज

GRAVITATION

Some questions (Assertion–Reason type) are given below. Each question contains STATEMENT – 1 (Assertion) and STATEMENT – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct. So select the correct choice :

Choices are :

(A) Statement – 1 is True, Statement – 2 is True; Statement – 2 **is** a correct explanation for Statement – 1.
(B) Statement – 1 is True, Statement – 2 is True; Statement – 2 **is NOT** a correct explanation for Statement – 1.
(C) Statement – 1 is True, Statement – 2 is False.
(D) Statement – 1 is False, Statement – 2 is True.

172. **STATEMENT – 1**
Escape velocity is independent of the angle of projection.
STATEMENT – 2
Escape velocity from the surface of earth is $\sqrt{2gR}$ where R is radius of earth.

173. **STATEMENT – 1**
Work done in gravitational field in cyclic process is zero.
STATEMENT – 2
Work done in conservative field does not depend upon path.

174. **STATEMENT – 1**
Gravitational potential is zero inside a shell.
STATEMENT – 2
Gravitational potential is equal to the work done in bringing a unit mass from infinity to a point inside gravitational field.

175. **STATEMENT – 1**
In its elliptical orbit around the Sun, the Earth is closer to the Sun during summer then during winter in northern hemisphere.
STATEMENT – 2
The angular momentum of the Earth about the Sun is conserved.

176. **STATEMENT – 1**
The plane of the orbit of an artificial satellite must contain the centre of the Earth.
STATEMENT – 2
For an artificial satellite, the necessary centripetal force is provided by gravity.

177. **STATEMENT – 1**
A spherically symmetric shell produces no gravitational field anywhere.
STATEMENT – 2
The field due to various mass elements cancels out, everywhere inside the shell.

178. **STATEMENT – 1**
Weight of an object on the Earth is more in mid–night than what it is at the noon.

STATEMENT – 2
At noon gravitational pull on the object by the Sun and that by the earth are oppositely directed, and in the mid–night they are in the same direction.

179. **STATEMENT – 1**
When a planet approaches the point which is farthest from the Sun, its orbital speed decreases.

STATEMENT – 2
Work done on the planet by the gravitational force exerted by the Sun is negative.

180. **STATEMENT – 1**
Comets move around the Sun in elliptical orbits. The gravitational force on the comet due to Sun is not normal to the comet's velocity, but the work done by the gravitational force over every complete orbit of the comet is zero.

STATEMENT – 2
Gravitational force is a conservative force and the work done by a conservative force over a closed path is always zero.

181. **STATEMENT – 1**
For the planets orbiting around the Sun, angular speed, linear speed, KE changes with time, but angular momentum remains constant.

STATEMENT – 2
No torque is acting on the rotating planet, so its angular momentum is constant.

182. **STATEMENT – 1**
Space rockets are usually launched in the equatorial line from west to east.

STATEMENT – 2
The acceleration due to gravity is minimum at the equator.

183. **STATEMENT – 1**
The escape speed of a body of mass m is v_e. The escape speed of another body of mass 2m for same planet is v_e.

STATEMENT – 2
The escape speed of a body for a given planet is independent of mass of body.

184. **STATEMENT – 1**
A planet of mass M is moving around the Sun in elliptical orbit. Angular momentum of planet about Sun remains constants but its KE changes with time.

STATEMENT – 2
Net torque on planet about Sun is zero, so its angular momentum remains conserved.

185. **STATEMENT – 1**
Escape velocity from surface of a particular planet is V. If a tunnel is made inside the surface, the escape velocity from a point inside the tunnel must be greater than V.

STATEMENT – 2
Gravitational force is a conservative force.

186. **STATEMENT – 1 :** If an object is projected from earth surface with escape velocity path of object will be parabola.

STATEMENT – 2 : When object is projected with velocity less than escape velocity from horizontal surface and greater than orbital velocity. Path of object will be ellipse.

187. **STATEMENT – 1 :** Rate of change of weight near the earth's surface with height h is proportional to h^o.

STATEMENT – 2 : Since gravitational potential is given by $v = -\frac{GM}{r}$.

188. **STATEMENT – 1 :** A particle is at a height R from the surface of earth. Here R is radius of earth. If mass of particle is m then its gravitational potential energy is mgR.

STATEMENT – 2 : If a particle is slowly lifted above the surface of earth then work is done by external agent. Work done by external agent is stored in form of potential energy.

189. **STATEMENT – 1 :** Two particles are to be projected from the surface of earth so that particles just leave the gravitational field of earth. One particle is projected vertically upward and another is at an angle of 45° with vertical. Speed given to both particles is same.

STATEMENT – 2 : Escape speed does not depend upon angle of projection.

190. **STATEMENT – 1 :** For the planets orbiting around the sun, angular speed, linear speed K.E. changes with time, but angular momentum remains constant.

STATEMENT – 2 : No torque is acting on the rotating planet. So its angular momentum is constant

191. **STATEMENT – 1 :** For a satellite revolving very near to earth's surface the time period of revolution is given by 1 hour 24 minutes.

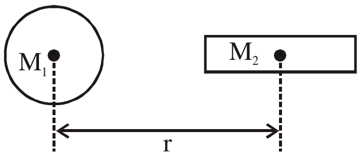
STATEMENT – 2 : The period of revolution of a satellite depends only upon its height above the earth's surface.

192. **STATEMENT – 1 :** Kepler's 2^{nd} law can be understood by conservation of angular momentum principle.

STATEMENT – 2 : Kepler's 2^{nd} law is related with areal velocity which can further be proved to be based on conservation of angular momentum as $\left(\frac{dA}{dt}\right) = \left(\frac{1}{2}r^2\omega\right)$.

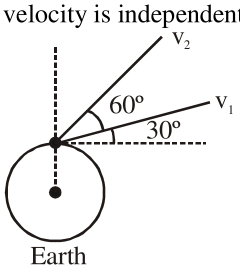
193. **STATEMENT – 1 :** The force of gravitation between sphere and a rod of mass M_2 is $= \frac{GM_1M_2}{r^2}$.

STATEMENT – 2 : Newton's law of gravitation holds correct for point masses.



194. **STATEMENT – 1 :** The value of escape velocity from the surface of earth at 30° and 60° is $v_1 = 2v_e$, $v_2 = \frac{2}{\sqrt{3}} v_e$.

STATEMENT – 2 : The value of escape velocity is independent of angle of projection.



195. **STATEMENT – 1 :** If earth suddenly stops rotating about its axis, then the acceleration due to gravity will become same at all the places.

STATEMENT – 2 : The value of acceleration due to gravity is independent of rotation of earth.

196. **STATEMENT – 1 :** Orbital velocity of a satellite is greater than its escape velocity.

STATEMENT – 2 : Orbit of a satellite is within the gravitational field of earth where as escaping is beyond the gravitational field of earth.

197. **STATEMENT – 1 :** Two stars start moving towards each other due to mutual force of attraction but centre of mass remains at rest.

STATEMENT – 2 : External force is absent.

198. **STATEMENT – 1 :** When planet moves in elliptical orbit around Sun. Its angular momentum about sun remains conserved.

STATEMENT – 2 : Total energy of planet remains conserved.

199. **STATEMENT – 1 :** Satellite is put in an orbit at a height where air resistance is present. Then orbital velocity of the satellite will decrease.

STATEMENT – 2 : Due to air resistance a lot of heat will be produced which may burn satellite.

200. **STATEMENT – 1 :** An astronaut in a satellite looses his mass which converts into energy.
because
STATEMENT – 2 : Loss in mass will change the orbital speed of the satellite.

201. **STATEMENT – 1 :** The magnitude of gravitational potential at the surface of solid sphere is less than that of the centre of sphere.

STATEMENT – 2 : Due to solid sphere, gravitational potential is same within the sphere.

202. **STATEMENT – 1 :** Smaller the orbit of a planet around the sun, shorter is the time if takes to complete.

STATEMENT – 2 : According to Kepler's Third Law of planetary motion, square of time period is proportional to cube of mean distance from sun.

203. **STATEMENT – 1 :** The value of acceleration due to gravity does not depend upon mass of the body.

STATEMENT – 2 : Acceleration due to gravity is a constant quantity.

Hint & Solution

172.	(A)						
173.	(A)	174.	(D)	175.	(D)	176.	(B)
177.	(D)	178.	(D)	179.	(A)	180.	(A)
181.	(A)	182.	(B)	183.	(A)	184.	
185.	(B)	186.	(B)	187.	(B)	188.	(D)
189.	(A)	190.	(A)	191.	(A)	192.	(A)
193.	(D)	194.	(D)	195.	(C)	196.	(D)
197.	(A)	198.	(B)	199.	(B)	200.	(C)
201.	(C)	202.	(A)	203.	(C)		

172. Using only energy conservation $\frac{1}{2}mv_e^2 = \frac{GMm}{R} = 0 + 0$.

173. Work done in conservative field in cyclic process is zero.

174. Work will be done only in bringing the unit mass from infinity upto the surface of shell because inside shell there is no gravitational field and in moving inside the shell no work will be done.

175. Statement 1 is true otherwise the orbit would be unstable.

177. Although no gravitational field is produced inside a symmetric shell, it produces a field at points outside of shell.

181. The torque on a body is given by $\vec{\tau} = \frac{d\vec{\tau}}{dt}$. In case of planet orbiting around the Sun no torque is acting on it.

$\Rightarrow$ L (angular momentum) = constant.

187. $$g' = g\left(1 - \frac{2h}{R}\right); \ \Delta g = g - g' = g\left(\frac{2h}{R}\right)$$

$$\frac{d\omega}{dh} = \frac{d}{dh}(m\Delta g) = m\frac{d}{dh}\Delta g = m\frac{d}{dh}\left(\frac{2gh}{R}\right)$$

$$= \frac{2mg}{R} = \text{constant.}$$

188. Potential energy of particle at a height R is

$$GPE = -\frac{GMm}{2R} = -\frac{mgR}{2}.$$

189. $$U_e\sqrt{\frac{2GM}{R}}$$

$$= \sqrt{2gR} = 11.2 \text{ km/s}$$

which doe not depend upon angle of projection.

190. The torque on a body is given by $\vec{\tau} = \frac{d\vec{L}}{dt}$. In case of planet orbiting around sun no torque is acting on it.

$$\frac{d\vec{L}}{dt} = 0 \Rightarrow \vec{L} = \text{constant}$$

191. The time period of satellite which is very near to earth is given by $T = 2\pi\sqrt{\frac{R}{g}} \simeq 84\,\text{min} = 1\text{hr}.24\,\text{min}$.

192. $$\frac{dA}{dt} = \frac{1}{2}r^2\frac{d\theta}{dt} = \frac{1}{2}r^2\omega$$

$$\frac{mr^2\omega}{2m} = \frac{2}{2m} = \text{constant}$$

$\therefore$ L = constant.

193. We can take sphere as a point mass lying at its centre, but the rod will not be taken as point mass lying at its centre of mass.

194. The value of escape velocity is derived from the conservation of (TME) method and energy is independent of direction.

195. The value of g at any place is given by

$g' = g - \omega^2 R_e \cos^2 \lambda$

if $\omega = 0$ $\therefore$ $g' = g$ is the value of g will be same at all places.

196. $v_e = \sqrt{2}\ v_0$

197. Angular momentum is conserved because net torque is zero.

198. Decrease in speed and production of heat, both take place.

199. Orbital speed is independent of mass of satellite.

201. $$V_{in} = \frac{GM}{2R^3}[3R^2 - r^2]$$

At surface, $V_s = \frac{GM}{R}$ [at r = R]

$$V_{in} = \frac{3}{2}V_s$$

$$V_{in} > V_s$$

V is not same everywhere as indicated by V_{in}.

202. According to Kepler's Third Law of motion, the square of the time period of a planet about the sun is proportional to the cube of the semi major axis of the ellipse or mean distance of the planet from the sun i.e., $T^2 \propto a^3$. when a is smaller, shorter is the time period.

203. Acceleration due to gravity is given by $g = \frac{GM}{l^2}$. Thus it does not depend on mass of body on which it is acting. Also it is not a constant quantity it change with change in value of both M and R (distance between two bodies).