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Gravitation

Exam — Gravitation

Pre-med/IB-style questions covering Newton's law of gravitation, gravitational field/weight, potential energy and work, satellites/orbits (Kepler relationships), escape speed, and common conceptual traps (field vs potential, weightlessness, scaling with distance).

70 items — Printable Exam

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1 Two point masses m_1 and m_2 are separated by distance r . Which expression gives the magnitude of the gravitational force between them?

- A $F = G(m_1 + m_2)/r$
- B $F = Gm_1m_2/r$
- C $F = Gm_1m_2/r^2$
- D $F = (1/2)Gm_1m_2/r^2$
- E $F = G(m_1 - m_2)/r^2$



2 If the distance between two masses is doubled ($r \rightarrow 2r$), the gravitational force magnitude becomes:

- A Twice as large
- B Half as large
- C One quarter as large
- D Four times as large
- E Unchanged



3 If both masses in a two-body system are doubled ($m_1 \rightarrow 2m_1$ and $m_2 \rightarrow 2m_2$) while r stays the same, the gravitational force becomes:

- A Twice as large
- B Four times as large
- C Eight times as large
- D Half as large
- E Unchanged





4 Earth exerts a gravitational force on the Moon. Compared to this force, the gravitational force the Moon exerts on Earth is:



- A** Larger, because the Moon moves around Earth
- B** Smaller, because Earth is more massive
- C** Equal in magnitude and opposite in direction
- D** Zero, because Earth is the "source" of gravity
- E** Equal in direction and magnitude

5 Which statement best distinguishes mass and weight?



- A** Mass depends on location; weight is constant everywhere
- B** Mass is the gravitational force; weight is the amount of matter
- C** Mass is a measure of inertia; weight is the gravitational force on that mass
- D** Mass and weight are the same physical quantity
- E** Weight is measured in kg; mass in newtons

6 In a vacuum near Earth's surface, two objects of different masses are dropped from the same height. Which is correct about their accelerations?



- A** The heavier object accelerates more because gravity pulls harder on it
- B** The lighter object accelerates more because it has less inertia
- C** They accelerate at the same rate because gravitational and inertial mass cancel in $a = F/m$
- D** Neither accelerates because gravity is balanced by air resistance





- E Acceleration depends on shape only, not mass

7 The gravitational field strength g at a point is defined as:



- A $g = m/F$
- B $g = F/m$ (force per unit mass)
- C $g = Fm$
- D $g = Gm/r$
- E $g = r^2/GM$

8 Which unit can correctly describe gravitational field strength?



- A kg
- B N
- C N/kg
- D J
- E kg/s

9 Which statement correctly compares G and g ?



- A G depends on the planet; g is universal
- B G is universal; g depends on location (mass and radius of the planet)
- C G and g are the same constant written differently





- D g is universal; G depends on altitude
- E Both G and g depend on the test mass

10 At a point outside a spherical planet, the direction of the gravitational field vector is:



- A Tangential to the surface
- B Radially outward
- C Radially inward toward the planet's center
- D Always upward relative to an observer
- E Perpendicular to the radius

11 If we choose gravitational potential energy $U = 0$ at infinite separation, then for two masses attracting each other at distance r , U is:



- A Always positive
- B Always negative
- C Always zero
- D Positive only for circular orbits
- E Negative only if the masses are equal

12 Which statement correctly links gravitational work and potential energy for a conservative gravitational field?





- A $W_{\text{gravity}} = +\Delta U$
- B $W_{\text{gravity}} = -\Delta U$
- C $W_{\text{gravity}} = \Delta K$ only in space
- D W_{gravity} is always zero
- E W_{gravity} depends on the path taken

13 A satellite moves from a lower orbit (closer to Earth) to a higher orbit (farther from Earth). With $U(\infty)=0$, its gravitational potential energy:



- A Decreases (becomes more negative)
- B Increases (becomes less negative)
- C Stays the same
- D Becomes zero immediately
- E Must become positive

14 Which statement best describes gravity (in Newtonian physics) as a force field?



- A Gravity is non-conservative; work depends on path
- B Gravity is conservative; work depends only on initial and final positions
- C Gravity does no work in any motion
- D Gravity is conservative only on Earth, not in space
- E Gravity is conservative only for circular orbits





15 Far from Earth's atmosphere, at a distance from Earth's center of $2R$ (where R is Earth's radius), the gravitational field strength is approximately:

- A $2g$
- B $g/2$
- C $g/4$
- D $4g$
- E 0



16 Compared with sea level, a person's weight at the top of a high mountain is (ignoring Earth's rotation effects):

- A Slightly smaller
- B Slightly larger
- C Exactly the same
- D Zero
- E Negative



17 In an idealized model of Earth as a perfect sphere with uniform density, the gravitational field strength at Earth's exact center is:

- A Maximum
- B Equal to g at the surface
- C Half of surface g
- D Zero
- E Infinite





18 In the same uniform-density Earth model, the gravitational field strength at radius r inside Earth ($r < R$) is proportional to:



- A $1/r^2$
- B r
- C r^2
- D Constant (independent of r)
- E $1/r$

19 A classic result: outside a uniform spherical planet, the gravitational field is the same as if all the planet's mass were concentrated at its center. This is essentially due to:



- A Friction
- B The shell theorem for spherical symmetry
- C Kepler's second law
- D The conservation of kinetic energy
- E Air resistance

20 In the ideal shell theorem model, the gravitational field inside a hollow spherical shell (at any point inside) is:



- A Zero everywhere inside
- B Constant and nonzero
- C Maximum at the center





- D Pointing outward
- E Equal to GM/R^2 inside

21 An apple falls toward Earth. Which statement about the gravitational forces is correct?



- A Earth pulls harder on the apple than the apple pulls on Earth
- B The apple pulls harder on Earth because it is closer to Earth's center
- C Earth and apple pull on each other with equal magnitude forces
- D Only Earth pulls on the apple; the apple exerts no force
- E Forces are equal only if masses are equal

22 For a satellite of mass m in a circular orbit of radius r around a planet of mass M , the orbital speed v satisfies:



- A $v = GM/r$
- B $v = \sqrt{GM/r}$
- C $v = \sqrt{GMr}$
- D $v = GM/r^2$
- E $v = \sqrt{GMm/r}$

23 A satellite moves from a circular orbit of radius r to a circular orbit of radius $4r$ around the same planet. Its orbital speed changes by a factor of:





- A 4
- B 2
- C $1/2$
- D $1/4$
- E $\sqrt{2}$

24 A satellite moves from a circular orbit of radius r to a circular orbit of radius $4r$ around the same planet. Its orbital period changes by a factor of:



- A 2
- B 4
- C 8
- D 16
- E $1/8$

25 At a given orbit radius r , the escape speed v_{esc} is related to the circular orbit speed v_{circ} by:



- A $v_{\text{esc}} = v_{\text{circ}}$
- B $v_{\text{esc}} = \sqrt{2} \cdot v_{\text{circ}}$
- C $v_{\text{esc}} = 2 \cdot v_{\text{circ}}$
- D $v_{\text{esc}} = v_{\text{circ}}/2$
- E $v_{\text{esc}} = v_{\text{circ}}/\sqrt{2}$





26 Which statement best defines escape speed from a planet (ignoring air resistance)?



- A The speed needed to reach the top of the atmosphere
- B The speed needed so the object never returns, reaching infinity with zero final speed
- C The speed needed to orbit once
- D The speed needed so weight becomes zero instantly
- E The speed needed to cancel gravity at launch

27 Escape speed from a planet depends on:



- A Only the mass of the object trying to escape
- B Only the planet's radius
- C Only the planet's mass
- D The planet's mass and the launch distance from the planet's center
- E The object's shape and color

28 If a planet's mass doubles while its radius stays the same, the escape speed from its surface changes by a factor of:



- A 2
- B $\sqrt{2}$
- C $1/2$
- D $1/\sqrt{2}$
- E 4





29 A planet's mass doubles AND its radius doubles. Compared with the original planet, the escape speed from the surface is:



- A Larger
- B Smaller
- C The same
- D Twice as large
- E Half as large

30 A geostationary satellite must:



- A Orbit above the North Pole with any period
- B Have a period equal to Earth's rotation and orbit in the equatorial plane in the same direction as Earth rotates
- C Have zero speed relative to Earth
- D Be in a very low orbit to stay fixed
- E Have no gravity acting on it

31 Why is a geostationary satellite necessarily at a high altitude compared with low-Earth orbit satellites?



- A Because gravity is stronger higher up
- B Because only high altitude reduces air resistance to zero
- C Because a longer period requires a larger orbital radius for a stable orbit around Earth
- D Because satellite mass must be large





- E Because Earth's magnetic field forces it higher

32 Which orbit type is most suitable for repeatedly passing over (or near) Earth's poles for mapping and Earth observation?



- A Equatorial geostationary orbit
- B Polar orbit (near 90° inclination)
- C Orbit that stays fixed above one city
- D Only an elliptical orbit with apogee at the equator
- E Any orbit, because Earth rotates under it

33 Astronauts in the International Space Station feel "weightless" mainly because:



- A Gravity is zero in space
- B They are beyond Earth's gravitational field
- C They are in continuous free fall with the station, so the normal (support) force is near zero
- D Their mass decreases significantly in orbit
- E Centrifugal force cancels gravity in an inertial frame

34 Gravitational potential V at a point is defined as:



- A $V = U \cdot m$
- B $V = U/m$ (potential energy per unit mass)





- C $V = F \cdot m$
- D $V = mg$
- E $V = GMm/r^2$

35 Which is a correct unit for gravitational potential V ?



- A J
- B N
- C J/kg
- D N/kg²
- E kg/J

36 A spacecraft moves from distance r to distance $2r$ from a planet's center (r and $2r$ both outside the planet). With $U = -GMm/r$, the change in potential energy $\Delta U = U_{\text{final}} - U_{\text{initial}}$ is:



- A Negative
- B Positive
- C Zero
- D Always equal to mgh
- E Undefined because U is negative





37 A mass moves outward from a planet in a purely radial direction. Which statement about the work done by gravity is correct?

- A Gravity does positive work because the object is moving
- B Gravity does negative work because its force is inward while displacement is outward
- C Gravity does zero work because it is conservative
- D Gravity's work depends on the speed, not displacement
- E Gravity does negative work only if the object falls inward



38 The near-Earth approximation $U = mgh$ is valid mainly when:

- A h is comparable to Earth's radius
- B g is changing rapidly with height
- C h is much smaller than Earth's radius, so g is approximately constant over the height change
- D the object is moving at escape speed
- E the object is in orbit



39 A person's apparent weight is slightly smaller at the equator than at the poles mainly because:

- A g is larger at the equator due to Earth's bulge
- B Earth's rotation requires centripetal acceleration, reducing the normal force needed to support the person at the equator
- C Gravity points upward at the equator
- D Mass is smaller at the equator
- E Air density is lower at the equator





40 Which statement about gravity in low Earth orbit is correct?



- A** Gravity is essentially zero, so satellites float
- B** Gravity is still significant; satellites are in free fall while moving sideways fast enough to keep missing Earth
- C** Satellites stay up because there is no air resistance
- D** Satellites stay up because centrifugal force cancels gravity in an inertial frame
- E** Gravity points outward at that altitude

41 A satellite in circular orbit experiences no engine thrust. Which statement is correct about the satellite's acceleration?



- A** Acceleration is zero because speed is constant
- B** Acceleration is tangent to the orbit because it is moving forward
- C** Acceleration is toward Earth's center because gravity provides centripetal acceleration
- D** Acceleration points outward due to centrifugal force
- E** Acceleration alternates between inward and outward each orbit

42 A spacecraft is in a circular orbit. If its speed is increased slightly (but still below escape speed) at one point, its new path becomes:



- A** A smaller circular orbit immediately
- B** A larger circular orbit immediately
- C** An ellipse with the burn point as the perigee (closest point)
- D** An ellipse with the burn point as the apogee (farthest point)





- E A straight line tangent to the orbit

43 A spacecraft is in a circular orbit. If its speed is decreased slightly at one point (still moving forward), its new path becomes:



- A A larger circular orbit immediately
- B A smaller circular orbit immediately
- C An ellipse with the burn point as the apogee (farthest point)
- D An ellipse with the burn point as the perigee (closest point)
- E It instantly stops

44 For an elliptical orbit around a planet, where is the satellite's speed greatest?



- A At apogee (farthest point)
- B At perigee (closest point)
- C Speed is constant everywhere in an ellipse
- D At the midpoint of the orbit
- E It depends only on the satellite mass

45 Kepler's second law ("equal areas in equal times") is most directly connected to conservation of:



- A Energy
- B Linear momentum





- C Angular momentum
- D Mass
- E Charge

46 Two equal masses are placed at positions $x = -a$ and $x = +a$ on a line. At $x = 0$ (the midpoint), the net gravitational field is:



- A Maximum
- B Zero
- C Pointing to the right
- D Pointing to the left
- E Undefined because fields cannot cancel

47 Two masses are placed on a line: a large mass M and a smaller mass m separated by distance d . The point between them where the net gravitational field is zero is:



- A Exactly halfway between them
- B Closer to the larger mass M
- C Closer to the smaller mass m
- D At the position of the smaller mass
- E Outside the segment between them, always





48 At the midpoint between two equal masses, the net gravitational field is zero. What about the gravitational potential (with $V = 0$ at infinity) at that midpoint?

- A Zero, because the field is zero
- B Positive, because potentials add
- C Negative, because potentials (scalars) from both masses add and each is negative
- D Infinite
- E Undefined



49 At the point between two unequal masses where the net gravitational field is zero, which statement about the gravitational potential is correct (with $V=0$ at infinity)?

- A Potential is always zero where field is zero
- B Potential must be positive
- C Potential is negative (sum of two negative contributions) and generally not zero
- D Potential is undefined because forces cancel
- E Potential is zero only if masses are unequal



50 Which graph best represents how gravitational force magnitude F between two point masses changes with separation distance r ?

- A A straight line decreasing with r ($F \propto 1/r$)
- B A curve decreasing like $1/r^2$ (steep at small r , flattening at large r)
- C A straight line increasing with r
- D A constant horizontal line
- E A curve increasing like r^2





51 Which qualitative graph best represents gravitational potential energy U (with $U=0$ at infinity) as a function of separation r ?



- A U is positive and decreases toward 0 as r increases
- B U is negative and increases toward 0 as r increases
- C U is zero for all r
- D U increases without bound as r increases
- E U alternates sign periodically with r

52 Gravitational field lines around an isolated spherical mass point:



- A Outward because the mass is a "source"
- B Inward toward the mass
- C Tangential to circular paths
- D Randomly; there is no direction
- E Only upward

53 A small object is released from rest far from a planet and falls inward (no air resistance). Which energy change is correct as it falls?



- A Kinetic energy decreases and potential energy increases
- B Both kinetic and potential energy increase
- C Kinetic energy increases as gravitational potential energy decreases (becomes more negative)
- D Both kinetic and potential energy decrease





- E Total energy must increase because gravity adds energy

54 With the convention $V(\infty)=0$, the gravitational potential V at infinity is:



- A 0
- B $-\infty$
- C $+\infty$
- D Equal to g
- E Equal to GM

55 For a satellite in a circular orbit of radius r around mass M , which statement about energies is correct?



- A $K = -U$
- B $K = U/2$
- C $K = -U/2$
- D Total energy is zero
- E U is positive in orbit

56 For the same circular orbit, the total mechanical energy $E = K + U$ equals:



- A $+GMm/(2r)$
- B 0





- C $-GMm/(2r)$
- D $-GMm/r$
- E $+GMm/r$

57 A satellite experiences a small amount of atmospheric drag over time and gradually spirals to a lower circular orbit. After it has settled into a lower circular orbit, its orbital speed compared to before is:



- A Smaller, because drag slows everything
- B The same
- C Larger, because circular orbit speed increases at smaller radius ($v \propto 1/\sqrt{r}$)
- D Zero, because it eventually stops
- E Negative (reverses direction)

58 Tides on Earth are primarily caused by:



- A Earth's rotation creating extra gravity
- B The difference (gradient) in gravitational pull across Earth's diameter
- C The Moon's magnetic field
- D Air pressure changes from day to night
- E Friction between Earth and space

59 The Moon raises stronger tides on Earth than the Sun mainly because:





- A The Moon is more massive than the Sun
- B Tidal effects depend strongly on distance; the Moon is much closer even though it is less massive
- C The Sun's gravity does not reach Earth
- D The Moon rotates faster than the Sun
- E The Sun has no gravitational field in space

60 If you wanted an Earth satellite with the shortest possible orbital period (ignoring atmospheric drag limits), you would choose:



- A A very high orbit, because the path is smoother
- B A very low orbit close to Earth
- C A geostationary orbit
- D A polar orbit must always have the shortest period
- E Orbit period does not depend on radius

61 Which statement is true about gravitational force compared with electric force (in basic physics models)?



- A Gravitational forces can be repulsive, but electric forces cannot
- B Gravitational force is always attractive between masses; electric force can be attractive or repulsive
- C Both forces are always repulsive
- D Electric force is always weaker than gravity
- E Gravity depends on charge, not mass





62 A spacecraft moves closer to a planet (r decreases). What happens to the gravitational potential energy $U = -GMm/r$?

- A U increases (becomes less negative)
- B U decreases (becomes more negative)
- C U stays constant because gravity is conservative
- D U becomes zero
- E U becomes positive



63 If an object is launched from a planet's surface with speed greater than escape speed (ignoring air resistance), which statement is correct?

- A It will rise to a maximum height and then return
- B It will move away forever, reaching infinity with nonzero speed
- C It will enter a circular orbit automatically
- D Gravity becomes zero immediately so it stops accelerating
- E It must move in a straight line with constant speed right away



64 A projectile is launched from very far away toward a planet. Neglecting atmosphere, which statement is correct about its speed as it falls inward?

- A It slows down because gravity is attractive
- B It speeds up because gravitational potential energy decreases and converts to kinetic energy
- C Its speed stays constant because gravity is conservative
- D It can only move if a rocket engine pushes it
- E It speeds up only if it is heavy





65 Hypothetical planet: its mass stays the same, but its radius is compressed to half its original value. The surface gravitational field strength g changes by a factor of:



- A $1/2$
- B 2
- C 4
- D $1/4$
- E Unchanged

66 Two planets have the same surface gravitational field strength g , but planet A has a larger radius than planet B. Which statement must be true?



- A Planet A has smaller mass
- B Planet A has larger mass (because M must scale with R^2 to keep g constant)
- C They must have equal mass
- D Planet A must have lower density
- E It is impossible for two planets to have the same g

67 A student says: "If the gravitational field at a point is zero, then a test mass placed there has zero gravitational potential energy." Which response is best?



- A Correct, because zero field means zero energy
- B Incorrect: potential energy depends on potential, and potential can be nonzero even where field is zero
- C Correct only if the test mass is 1 kg





- D Correct only if there is exactly one mass present
- E Incorrect because potential energy must always be positive

68 A spacecraft moves from point A to point B in space where gravity is the only force. If gravitational potential energy increases ($\Delta U > 0$), then the work done by gravity is:



- A Positive
- B Negative
- C Zero
- D Always equal to mg
- E Always equal to the change in momentum

69 A small object is released from rest at distance r from a planet and falls inward. If it reaches distance $r/2$ (ignoring atmosphere), which statement is correct about its gravitational potential energy change?



- A U increases because it moved closer
- B U decreases (becomes more negative) because $1/r$ increased
- C U stays the same because only kinetic energy changes
- D U becomes zero at $r/2$
- E U becomes positive at $r/2$





70 Why is Earth's gravitational pull on the Moon not causing the Moon to crash straight into Earth?

- A** Because gravity does not act in space
- B** Because the Moon's sideways (tangential) velocity makes it continuously fall around Earth, creating an orbit
- C** Because the Moon has no mass
- D** Because centrifugal force perfectly cancels gravity in an inertial frame
- E** Because Earth repels the Moon gravitationally







#	Ans	Answer Text
1	C	$F = Gm_1m_2/r^2$
2	C	One quarter as large
3	B	Four times as large
4	C	Equal in magnitude and opposite in direction
5	C	Mass is a measure of inertia; weight is the gravitational force on that ...
6	C	They accelerate at the same rate because gravitational and inertial mass...
7	B	$g = F/m$ (force per unit mass)
8	C	N/kg
9	B	G is universal; g depends on location (mass and radius of the planet)
10	C	Radially inward toward the planet's center
11	B	Always negative
12	B	$W_{\text{gravity}} = -\Delta U$
13	B	Increases (becomes less negative)
14	B	Gravity is conservative; work depends only on initial and final position...
15	C	$g/4$
16	A	Slightly smaller
17	D	Zero
18	B	r
19	B	The shell theorem for spherical symmetry
20	A	Zero everywhere inside
21	C	Earth and apple pull on each other with equal magnitude forces
22	B	$v = \sqrt{(GM/r)}$
23	C	1/2
24	C	8
25	B	$v_{\text{esc}} = \sqrt{2} \cdot v_{\text{circ}}$
26	B	The speed needed so the object never returns, reaching infinity with zer...
27	D	The planet's mass and the launch distance from the planet's center
28	B	$\sqrt{2}$
29	C	The same
30	B	Have a period equal to Earth's rotation and orbit in the equatorial plan...
31	C	Because a longer period requires a larger orbital radius for a stable or...
32	B	Polar orbit (near 90° inclination)
33	C	They are in continuous free fall with the station, so the normal (suppor...
34	B	$V = U/m$ (potential energy per unit mass)
35	C	J/kg
36	B	Positive
37	B	Gravity does negative work because its force is inward while displacemen...
38	C	h is much smaller than Earth's radius, so g is approximately constant ov...



