



STEM Careers Project



STEM Careers Project is a joint venture of the Higher Education Commission and Pakistan Atomic Energy Commission, for grooming talented students for careers in Science, Technology; Engineering & Mathematics (STEM).

Screening TEST: Physics NSTC-21, June 29, 2024

Maximum Marks: 100

Maximum Time: 3 hours

Check List: Before attempting this question paper please make sure that:

- i) Paper contains 8 pages including this page and no page is torn or missing
- ii) Part I consists of 20 multiple choice questions, Part II contain 50 multiple choice questions and Part III contains descriptive questions
- iii) Answer Sheet for MCQs of Part-I & II, and Answer Booklet for Part III

1. Part I has 5 multiple-choice questions (MCQs) from each of the subjects of Biology, Computer, Chemistry, Mathematics and Physics. There is a choice between Biology or Computer only, rest of the three subjects are compulsory for every candidate. For Biology or Computer one must blacken the corresponding circle in the answer sheet.
2. Part I has 20 MCQs and carries 20 marks. The MCQ portion of the relevant subject of Part II carries 50 Marks. Correct answer carries +1 mark; 1/3 mark will be deducted for each incorrect answer.
3. In Part I and Part II, there are four choices (a, b, c, d) corresponding to each multiple-choice question. Blacken one of these choices, which in your opinion is correct. Rough work may be done in the Answer Booklet for Part III by clearly specifying 'Rough Work'.
4. The descriptive question(s) of Part III should be solved in the Answer Booklet for Part III. This part carries 30 Marks.
5. You are recommended to give frank opinion about the test, including pointing out possible mistakes and legibility problems on the last page of the Answer Booklet. It is meant to motivate you to carefully read the question paper before attempting it. It may be used to discriminate between candidates having similar scores.
6. Recommended time for Part I is about 30 minutes and for Parts II and III is about one hour each. The rest of the time is for carefully reading the paper and commenting on it.
7. No leaf from the question paper or Answer Booklet is to be torn out as all these must be handed over to the examiner, even if no question has been attempted. Anyone found using unfair means would be disqualified.
8. You may use non-programmable calculators.
9. No questions will be entertained and no clarification will be made during the test. In case of doubt, please write down your remarks/comments on the last page of the Answer Booklet.
10. You must attempt all Parts of the paper. To qualify screening test one should pass both Parts I and the portion of Parts II and III that are relevant to the discipline in which you have applied to appear.
11. The term 'estimate' if used in the descriptive portion of Part III means that only an approximate answer is expected from the students. Similarly the term 'sketch' in Part III means drawing a rough graph, which looks like what you might expect from more careful considerations.
12. **Possession of CELL PHONE or any IMAGING DEVICE in the Examination Hall will be treated as an offence under unfair mean rules.**
13. Please put your pen down as soon as you hear the announcement of 'stop writing'.

Students will be short-listed for a one-week Training Camp on the basis of their performance on this Screening Test. Results will be posted on NSTC web page: www.stem.edu.pk. Successful candidates will also be informed about their result in about two months after the exam. Please make sure that we have your correct phone/fax number and e-mail address.

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Name: _____

Roll No: _____

PART-I

[CANDIDATE MUST ATTEMPT THIS PART]

**[It contains 20 MCQs, 5 from each biology/computer, chemistry, mathematics and physics,
for selection to the next phase]**

Choose either Biology or Computer and must blacken the correct option in the answer sheet.

BIOLOGY

1. During cellular respiration breakdown of glucose occurs in
a) Vacuole b) Golgi complex c) Cytoplasm d) Mitochondria
2. The following rays can cause cancer:
a) X-rays b) Gamma rays c) Alpha and beta particles d) All of these
3. The hypothesis that stands the test of time are called:
a) Law b) Null Hypothesis c) Principle d) Theories
4. Electric intensity is a ----- quantity.
a) vector b) scalar c) basic d) none of these
5. One coulomb is equal to the charge of-----electrons.
a) 6.25×10^{19} b) 6.24×10^{18} c) 6.24×10^{17} d) 6.25×10^{18}

OR

COMPUTER

1. Internet uses _____ to communicate between devices and networks.
a) HTTPS b) email c) internet protocol suite d) website
2. Which of the following creates user groups and assigns privileges to them?
a) Process management b) I/O management c) File management d) Network management
3. In C++, a pointer is
a) address of a variable b) constant value c) data type of an address variable d) variable for storing address
4. The programming technique where a function calls itself is known as
a) recursion b) encapsulation c) inline function d) it is a bug
5. Which of the following loop is always executed at least once:
a) for b) do while c) while d) counter loop

CHEMISTRY

6. The phenomenon of emission of light in a chemical reaction is known as
a) Chemiluminescence b) Photosensitization c) Luminescence d) None of these
7. Name the device used to measure the number of nuclear disintegration per minute
a) Cyclotron b) Geiger counter c) Cloud chamber d) Mass spectrograph
8. Which of the following bonds must be present in alkynes?
a) Single bond b) Double bond c) triple bond d) Hydrogen bond
9. When a solution contains equal concentration of hydroxyl and hydrogen ions its pH will be around
a) 0 b) 14 (c) 7 d) 10
10. Which is the most reactive element in the given list?
a) Fluorine b) Oxygen c) Nitrogen d) Iodine

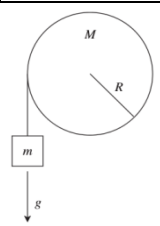
MATHEMATICS

11. A quadrilateral with vertices at $(0, -1), (3, 1), (3, -1), (0, 1)$ is a _____.
a) kite b) square c) parallelogram d) rectangle
12. The center of the circle, _____.
a) is a point on the circle b) lies outside of the circle c) lies inside of the circle d) none of these
13. What is the sum of all the divisors of 600?
a) 2060 b) 1860 c) 2160 d) 1890
14. What is the sum of the first nine prime numbers?
a) 100 b) 98 c) 80 d) 77
15. The equations $2x+7=3$ and $bx - 10 = -2$ have the same solution. What is the value of b?
a) -4 b) 6 c) 2 d) $3/2$

PHYSICS

16. A ball of mass m falls from rest onto a floor, from a height h . It makes elastic collisions with the floor repeatedly. The force exerted by it on the floor, averaged over a long time, is
a) mg b) $2 mg$ c) $3 mg$ d) proportional to m and h
17. While passing over an obstacle a light ray slightly bends round the corner. The phenomenon is known as ____:
a) Scattering b) Polarisation c) Diffraction d) Refraction
18. What is the orbital velocity of geo stationary satellite?
a) 4.15 km/s b) 2.78 km/s c) 3.08 km/s d) 6.66 km/s
19. What is the direction of electric and magnetic fields in an electromagnetic wave?
a) parallel to each other, b) at 90° to each other, c) at 45° to each other, d) at 120° to each other
20. What is the time period of a seconds pendulum?
a) 0.5 second b) 1.0 seconds c) 1.5 seconds d) 2.0 seconds

PART II – PHYSICS

21	Consider a car starts moving from rest with acceleration $a = 10.0 \text{ m/s}^2$, then continues uniformly, and finally stops with deceleration at the same rate a . Assume that the time taken for the whole journey is 40 s with an average velocity of 100 km/hour. What is the duration of the uniform motion?						
(a)	32 s	(b)	34 s	(c)	30 s	(d)	35 s
22	A particle has a radius vector which varies with time t as $\vec{r} = (1 - \beta t)t\vec{r}_0$, where \vec{r}_0 is a constant vector and β is a positive constant factor. What is the acceleration of the particle?						
(a)	$-2\beta\vec{r}_0$	(b)	$2\beta\vec{r}_0$	(c)	$\beta\vec{r}_0$	(d)	$-\beta\vec{r}_0$
23	Use the information in question 22. Let the particle starts at $t = 0$ and returns back to its original position after time Δt which is given by:						
(a)	β	(b)	$2/\beta$	(c)	$\beta/2$	(d)	$1/\beta$
24	Consider a mass slides on a horizontal frictionless track. It is connected to a spring fastened to a wall. Initially, the amplitude of the oscillations is A and the spring constant is k_1 . The spring constant then decreases adiabatically at a constant rate until the value k_2 is reached. (For example, suppose the spring is being dissolved by the nitric acid.) What is the new amplitude?						
(a)	$A\left(\frac{k_2}{k_1}\right)^{1/2}$	(b)	$A\left(\frac{k_2}{k_1}\right)^{1/4}$	(c)	$A\left(\frac{k_1}{k_2}\right)^{1/2}$	(d)	$A\left(\frac{k_1}{k_2}\right)^{1/4}$
25	Consider a block of mass 1.0 kg is moving with a velocity v . It collides with a block of mass 6.0 kg that is initially at rest. What is the velocity of the heavier block if the collision is perfectly elastic?						
(a)	$2v/5$	(b)	$3v/7$	(c)	$2v/7$	(d)	$3v/5$
26	A particle is placed 10 cm from the center of a rough turntable. The turntable is steadily accelerated at 20 rad per squared second. When the angular velocity reaches 70 rad per second, the particle starts to slip. If the particle had originally been placed 15 cm from the center and the turntable accelerated as before, at what angular velocity would it have started to slip?						
(a)	1.2 rad/s	(b)	5.4 rad/s	(c)	7.8 rad/s	(d)	10 rad/s
27	Consider a solid cylinder of uniform density having mass M and radius R . A string of length L is completely wound around the cylinder and a small weight of mass m is attached to its end. Assume the mass of the string is negligible whereas $M = 30m$. The mass m is released from rest under the influence of gravity. What is the velocity of the mass m when the string is entirely unwound?						
(a)	$\sqrt{16gL}$	(b)	$\sqrt{8gL/2}$	(c)	$\sqrt{gL/8}$	(d)	$\sqrt{2gL}$
28	Consider a block of mass M sliding on a frictionless surface of ice at a uniform velocity of 20 m/s. The block reaches a rough patch on ice where the coefficient of kinetic friction is suddenly increased from 0 to 0.8. What is the distance the block slides before stopping?						
(a)	23.2 m	(b)	25.5 m	(c)	28.2 m	(d)	27.5 m
29	Consider a spring-mass system with oscillation frequency f . What is the new frequency of the oscillator if the spring constant is halved and mass is doubled?						
(a)	$f/2$	(b)	$2f$	(c)	$2.5f$	(d)	$f/4$
30	A uniform mass density cylinder of radius r and mass m rolls down a ramp of length d and height h . Assuming there is no slipping during the rolling, the speed of the cylinder at the bottom of the ramp is given by:						
(a)	$\sqrt{2gd}$	(b)	$\sqrt{2gh}$	(c)	$\sqrt{qhr/d}$	(d)	$\sqrt{4qh/3}$
31	What is the recoil velocity of a rifle of mass 5.0 kg, if a bullet of mass 0.01 kg is shot at a speed of 250 m/s?						
(a)	-0.5 m/s	(b)	0.5 m/s	(c)	0.25 m/s	(d)	-0.25 m/s
32	A tennis ball is thrown vertically upward from the top of a pole of height 30.0 m (from ground) at time $t = 0$. The ball on its way back lands down on ground. Assuming air resistance is negligible, the time elapsed from $t = 0$ to the time when the ball hits the ground is approximately:						
(a)	4.27 s	(b)	3.65 s	(c)	5.24 s	(d)	4.92 s

33	Consider the launch of a rocket carrying satellite. After 1.2 s of liftoff, it clears the top of its launch platform, 65 m above the ground. It reaches 1.1 km above the ground after an additional time of 4.9 s. What is the magnitude of the average velocity of the rocket for the 4.9 s part of its flight?						
(a)	196 m/s	(b)	211 m/s	(c)	205 m/s	(d)	217 m/s
34	Consider an old building is blown using dynamite by a demolition team. Assume that the explosion results in debris in all directions and angles and there is no air resistance. The largest distance where debris is found is 50 m from the explosion. What is the maximum speed at which debris was blown outward?						
(a)	22 m/s	(b)	25 m/s	(c)	28 m/s	(d)	30 m/s
35	A physical pendulum performs small oscillations about the horizontal axis with a frequency $\omega_1 = 15.0s^{-1}$. When a small body of mass $m = 50 g$ is fixed to the pendulum at a distance $l = 20cm$ below the axis, the oscillation frequency becomes equal to $\omega = 10.0s^{-1}$. Find the moment of inertia of the pendulum relative to the oscillation axis.						
(a)	$10gm^2$	(b)	$5gm^3$	(c)	$5gm^3$	(d)	$0.5gm^2$
36	Consider an airliner is flying at angle $\theta = 26.0^\circ$ above the horizontal with velocity $v = 80.0 m/s$. Assume that a luggage fall from the luggage compartment when airplane is 120 m above a point 'x' on the ground. How far the luggage will drop from point 'x' if the air resistance is neglected?						
(a)	685 m	(b)	670 m	(c)	696 m	(d)	704 m
37	A car is moving in a straight line with a velocity 110 km/h. If brakes are applied and maximum deceleration is $7 m/s^2$, what is the minimum distance for car to stop?						
(a)	70.7 m	(b)	69.7 m	(c)	62.7 m	(d)	66.7 m
38	A tennis ball initially at rest is dropped from a height h into a pond. It touches the water surface in 4 seconds. With what speed should the ball be thrown to reach the surface of water in 2 seconds?						
(a)	30.4 m/s	(b)	29.4 m/s	(c)	25.4 m/s	(d)	28.4 m/s
39	Consider an airplane flying with a constant velocity of 550 km/h at a constant height of 3 km. When the airplane is exactly above a marked point 'A' on the ground, a box is dropped which hits the ground at point B. When the box hits the ground what the approximate position of airplane is as measured from point A?						
(a)	4000 m	(b)	3848 m	(c)	3665 m	(d)	3778 m
40	Consider a mass $M = 2 kg$ placed on a smooth table and is attached by a massless string and a frictionless pulley to a second mass $m=0.02 kg$ hanging at the edge of the table. Assume that the system is released from the rest and mass M moves towards the pulley. To travel a distance of 0.5 m from the starting point, how much time will be taken?						
(a)	3.2 s	(b)	3.5 s	(c)	3.8 s	(d)	4.0 s
41	Consider a wooden block of mass m_1 connected with an elastic spring of spring constant k . The block lies on a smooth table. A dart of mass m_2 is thrown with a constant horizontal velocity v . The dart sticks with the box which slides on the table. If $m_1 = 8m_2$, the minimum distance through which the block compresses the spring is:						
(a)	$\sqrt{\frac{2m_1v^2}{k}}$	(b)	$\sqrt{\frac{m_1}{kv}}$	(c)	$\sqrt{\frac{m_1v^2}{3k}}$	(d)	$\sqrt{\frac{m_1v^2}{9k}}$
42	A mass of 1.0 kg is attached to a string and is rotated in a vertical orbit of radius 1.0 m. The speed of rotation is constant. The minimum speed to keep the string pulled tight is given by:						
(a)	3.0 m/s	(b)	3.13 m/s	(c)	2.51 m/s	(d)	2.95 m/s
43	The angular speed of the minute hand of a watch is:						
(a)	$1800/\pi rad/s$	(b)	$60/\pi rad/s$	(c)	$\pi/1800 rad/s$	(d)	$\pi/60 rad/s$
44	Assume we have a pendulum clock which gives correct time on earth surface. We take this clock to another planet where the acceleration due to gravity is reduced to $1.4 m/s^2$. By what factor the time-period of the pendulum at other planet changes as compared to its time-period at earth?						
(a)	$\sim\sqrt{7.5}$	(b)	$\sim\sqrt{6}$	(c)	$\sim\sqrt{6.5}$	(d)	$\sim\sqrt{7}$
45	The amplitude of oscillation of a simple pendulum is increased from 2° to 6° . By what factor its maximum acceleration changes?						

(a)	3	(b)	6	(c)	1/3	(d)	1/6
46	Consider a vibration sensitive equipment of mass 1.0 kg is being transported in a box of mass 4.0 kg. The equipment can tolerate vibration frequencies up to 10 s^{-1} . The box is supported by four springs. To design the system to keep the equipment safe, we must know the upper limit of spring constant k to limit the vibrations below the critical value. What is that limit?						
(a)	4934 N/m	(b)	5058 N/m	(c)	5132 N/m	(d)	4867 N/m
47	A 12 m long pendulum initially hanging at equilibrium is given a velocity of 0.3 m/s. The amplitude of the subsequent oscillations is:						
(a)	0.28 m	(b)	0.30 m	(c)	0.33 m	(d)	0.41 m
48	An ideal spring is suspended in a vertical position from the ceiling. If a mass of 2.0 kg is suspended from it at rest, the spring stretches by 6.0 cm from its original length. An external force in the downward direction is then applied to the mass, causing the spring to extend by an additional 10 cm. While the force is being applied to extend the spring, the work performed by the spring is:						
(a)	3.5 J	(b)	-3.6 J	(c)	-3.1 J	(d)	3.0 J
49	Approximately how many swings a pendulum of length 2.25 m perform in one hour?						
(a)	1800	(b)	1200	(c)	1600	(d)	1400
50	What is the period of oscillation of a 1.0 kg mass attached to a spring lying on a smooth horizontal table if the extension in the spring is 0.1 m when hung vertically?						
(a)	0.59 s	(b)	0.55 s	(c)	0.63 s	(d)	0.68 s
51	Suppose there is a light source whose power is $P = 40 \text{ W}$. A student is standing at a distance of 10 m from this source. If the radius of the pupil (a variable aperture through which light enters the eye) is 2mm and the wavelength of the light is 589 nm, How many photons strike the student's eye per second?						
(a)	$\sim 12 \times 10^{12}$ [photons/s]	(b)	$\sim 12 \times 10^8$ [photons/s]	(c)	$\sim 12 \times 10^{11}$ [photons/s]	(d)	$\sim 12 \times 10^{15}$ [photons/s]
52	A vessel is divided into two parts of equal volume by a partition in which there is a very small hole. Initially, each part contains gas at 300K and a low-pressure p . One part of the vessel is now heated to 600K while the other is maintained at 300K. If a steady-state is established when the rate at which molecules pass through the hole from each side is the same, find the resulting pressure difference between the two parts.						
(a)	0.62 P	(b)	0.48 P	(c)	0.29 P	(d)	0.55 P
53	The plates of a parallel-plate capacitor of area 10^{-2} m^2 are separated by a distance of 10mm. A layer of dielectric 3.0 mm thick of relative permittivity 6.0 lies between the plates and is adjacent to one plate. What is the capacitance of the capacitor if the remaining space is air?						
(a)	$11.8 \times 10^{-9} F$	(b)	$11.8 \times 10^{-18} F$	(c)	$11.8 \times 10^{-12} F$	(d)	$11.8 \times 10^{-10} F$
54	Consider a block of mass 12kg is moving towards east at 4 meters per second. It collides head on with another block of mass 6 kg moving west at 2 meters per second. What is the loss in kinetic energy in this collision if both blocks move together after the collision?						
(a)	50 J	(b)	62 J	(c)	84 J	(d)	72 J
55	A particle initially at rest explodes into three equal-mass particles in a situation where no external forces are acting. Two of the resulting particles move at equal speeds v and at a right angle to each other. What is the speed of the third particle?						
(a)	v	(b)	$v/\sqrt{2}$	(c)	$\sqrt{2}v$	(d)	$2v$
56	A ball of mass $m = 0.5 \text{ kg}$ is attached to the end of a string of length $L = 0.5 \text{ m}$. The ball is rotated on a horizontal circular path about the vertical axis. The maximum tension that the string can bear is 324 N. The maximum possible value of the angular velocity of the ball is?						
(a)	9 rad/s	(b)	18 rad/s	(c)	27 rad/s	(d)	36 rad/s
57	A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 m/s. A plumb bob is suspended from the roof of the car by a light rigid rod of length 1 m. The angle made by the rod with the vertical is?						
(a)	0°	(b)	30°	(c)	45°	(d)	60°

58	Alice stands 20 m from a wall and Bob stands 10 m from the same wall. Alice throws a ball at an angle of 30° above the horizontal, and it collides elastically with the wall. How fast does Alice need to throw the ball so that Bob will catch it? Consider Alice and Bob to be the same height, and both are on the same perpendicular line from the wall.						
(a)	13 m/s	(b)	16 m/s	(c)	19 m/s	(d)	22 m/s
59	A sportsman leaps into the air and catches a ball while both are in midair. Which undergoes the smaller change in momentum, the sportsman or the ball?						
(a)	The ball does.						
(b)	The sportsman does.						
(c)	The change in momentum is the same for both the sportsman and the ball.						
(d)	You can't tell without knowing the final velocity of the combined sportsman-ball mass						
60	If we compare a photon of red light with a photon of blue light, the photon of blue light has a						
(a)	lower frequency	(b)	longer wavelength	(c)	smaller momentum	(d)	greater energy
61	A 1.5 kilogram lab cart is accelerated uniformly from rest to a speed of 2.0 meters per second in 0.50 second. What is the magnitude of the force producing this acceleration?						
(a)	0.70 N	(b)	3.0 N	(c)	1.5 N	(d)	6.0 N
62	If the momentum of object with different masses is same. Then the object having largest K.E value will be the object						
(a)	with Least mass	(b)	with Highest mass	(c)	having Least velocity	(d)	having Highest velocity
63	A man weights 735 N is in a stationary lift. What will be his weight if the lift starts moving up with an acceleration 2.5 m/s^2						
(a)	735 N	(b)	547 N	(c)	922 N	(d)	1837 N
64	In a downward moving elevator having an acceleration of 9.8 ms^{-2} , the mass of a person will						
(a)	Remain the same	(b)	Become doubled	(c)	Become Half	(d)	Be Zero
65	Keeping the temperature of the ideal gas constant, if the pressure is doubled than the speed of sound will be						
(a)	doubled	(b)	Halved	(c)	Multiplied by $\sqrt{2}$	(d)	Unchanged
66	The power of lens is measured in						
(a)	Joule	(b)	Watt	(c)	Diopter	(d)	Meters
67	The chemical properties of all isotopes are						
(a)	Different	(b)	Alike	(c)	Depend upon atomic mass number	(d)	Neutral
68	The internal energy of an ideal gas depends upon only						
(a)	Pressure	(b)	Temperature	(c)	Volume	(d)	All of these
69	A bus is moving on a straight road with uniform acceleration. Marker posts are placed at 100m apart along the road. The bus speed is 10m/s when it passes one marker, and 14.14 m/s when it passes the next. Then the acceleration of the bus is						
(a)	0.67 m/s^2	(b)	1.5 m/s^2	(c)	2.5 m/s^2	(d)	3.0 m/s^2
70	In an experiment to determine the density of a steel ball, the uncertainty in the measurement of its mass was 1% and that of its diameter was 3%. What is the uncertainty in the calculated density of the steel ball?						
(a)	2%	(b)	5%	(c)	10%	(d)	15%

Part III: Physics-Descriptive Questions [30 Marks]

Question No 01:

(6+5+4)

- a) A thundercloud has a horizontal lower surface, area 25.0 km^2 , 750 m above the surface of the Earth. Using a capacitor as a model, calculate the electrical energy, E_1 , stored when its potential is $1.0 \times 10^5 \text{ V}$ above the earth potential. If the cloud rises to 1250 m :
- explain why the energy, E_2 , has increased or decreased
 - What is the change in electrical energy, ΔE ?
- b) A tank contains water to a depth of 1.0 m . Water emerges from a small hole in the vertical side of the tank at 20 cm below the surface. Determine:
- the speed at which the water emerges from the hole
 - the distance from the base of the tank at which the water strikes the floor on which the tank is standing.
- c) A closed wire loop in the form of a square of side 4.0 cm is placed with its plane perpendicular to a uniform magnetic field, which is increasing at the rate of 0.030 Ts^{-1} . The loop has a resistance of $2.0 \times 10^{-3} \text{ ohms}$. Calculate the current induced in the loop.

Question No 2:

(2+4+4+5)

A weight of mass M hangs from the end of a light vertical spring (with spring constant k) that is attached at its upper end, to a rigid support. When in equilibrium, the spring has an extension x_1 . The natural angular frequency of the system is ω .

- Determine x_1 in terms of ω .
- The mass vibrates about its equilibrium position, the spring having an extension (x_1+x) at time t . Obtain an expression for the total potential energy, V , of the system. The zero of the gravitational potential energy is taken to be at the equilibrium extension, x_1 .
- If the amplitude of the motion is A_1 , determine the maximum kinetic energy, T_1 , of the mass and the total energy, E_1 , of the system.
- The mass collides elastically with a stationary body of mass $M/2$ at $x=0$. Determine the new velocity, v_2 , after the collision and amplitude, A_2 , of the motion of mass M .

---End of paper---