



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-20, March 19, 2023

Maximum Marks: 100

Maximum Time: 3 hours

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

- Paper contains 9 pages including this page and no page is torn or missing
- Part I consists of 20 multiple choice questions, Part II contain 50 multiple choice questions and Part III contains descriptive questions
- Answer Sheet for MCQs of Part-I & II, and Answer Booklet for Part III

- 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.
- 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.
- Write your name on the space provided in the Answer Sheet for Part I and Part II. There are four choices (a, b, c, d) corresponding to each multiple-choice question. Blacken one of these choices as shown in the example, which in your opinion is correct. Rough work may be done in the Answer Booklet for Part III by clearly specifying 'Rough Work'.
- The descriptive question(s) of Part III should be solved in the Answer Booklet for Part III. This part carries 30 Marks.
- 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.
- 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.
- 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.
- You may use non-programmable calculators.
- 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.
- 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.
- 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.
- Possession of CELL PHONE or any IMAGING DEVICE in the Examination Hall will be treated as an offence under unfair mean rules.**
- 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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CHEMISTRY

6. All of the following substance are crystalline except:
a) Ice b) Diamond c) Sucrose d) Plastic
7. Diameter of an atom in the order of
a) $0.2\mu\text{m}$ b) 0.2mm c) 0.2nm d) 0.2pm
8. Which of the following is not a macromolecule
a) Sand b) Hemoglobin c) Diamond d) Maltose
- 9 About how many elements in the Periodic Table are Metals
a) 60% b) 65% (c) 70% d) 75%
10. Plasma is used in
a) Florescent bulb b) Neon signs c) Laser d) All of these

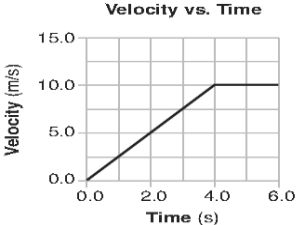

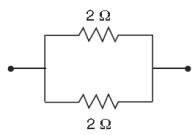
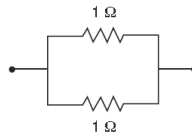
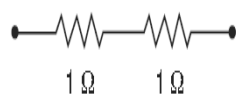
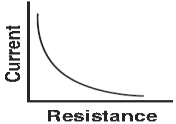

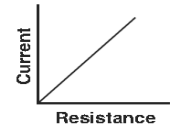

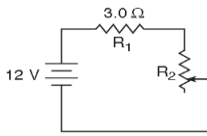
MATHEMATICS

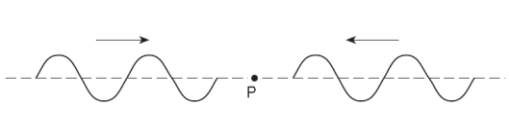
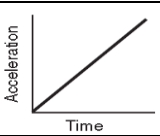
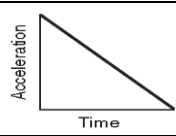
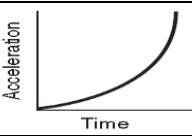
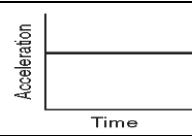
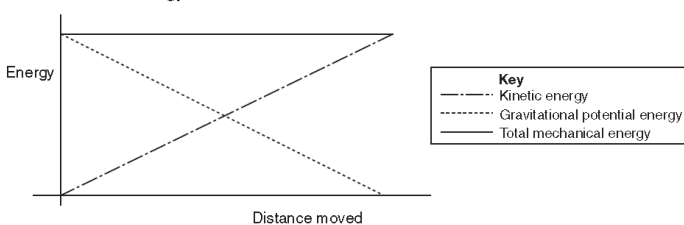

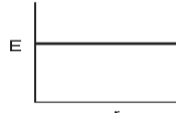

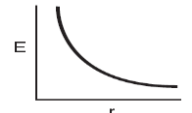
11. The distance between the points $(-2, 2)$ and $(1, 6)$ is
a) 25 units b) 5 units c) 7 units d) none of these
12. Angles that sum up to 90° are known as
a) Complementary b) Vertical angles c) Reflective angles d) Supplementary angles
13. Total number of lines passing through the point $(0,0)$ are
a) 0 b) 1 c) 2 d) ∞
14. The coordinates of the midpoint of points in plane with coordinates $(-2,8)$ and $(8,-2)$ are
a) $(0,0)$ b) $(3,3)$ c) $(2,2)$ d) $(8,8)$
15. If $x + \frac{1}{x} = 2$, then the value of $x^2 + \frac{1}{x^2}$ is:
a) $\frac{1}{4}$ b) 1 c) 3 d) 2

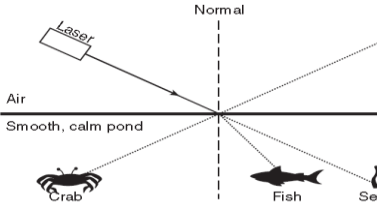

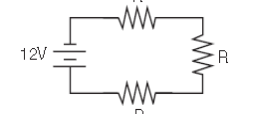
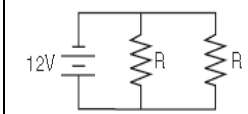
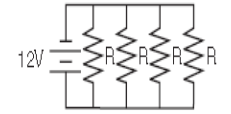
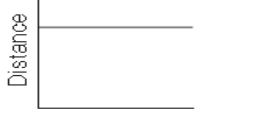

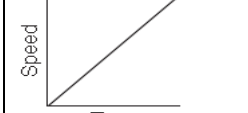
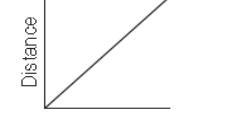
PHYSICS

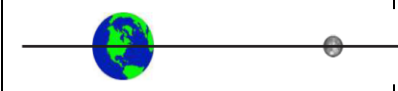
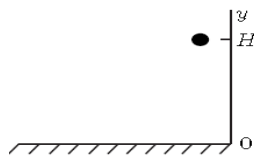
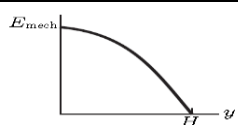
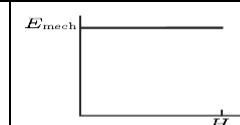
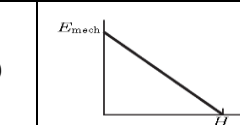
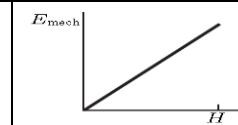
16. A net force of 10. Newtons accelerates an object at 5.0 m/s^2 . What net force would be required to accelerate the same object at 1.0 m/s^2 ?
a) 1.0 N b) 2.0 N c) 5 N d) 10 N
17. A 1,200-kilogram car traveling at 10. m/s hits a tree and is brought to rest in 0.10 second. What is the magnitude of the average force acting on the car to bring it to rest?
a) $1.2 \times 10^2 \text{ N}$ b) $1.2 \times 10^3 \text{ N}$ c) $1.2 \times 10^4 \text{ N}$ d) $1.2 \times 10^5 \text{ N}$
18. When a neutral metal sphere is charged by contact with a positively charged glass rod, the sphere
a) Loses electrons b) Loses protons c) Gains electrons d) Gains protons
19. An electric iron operating at 120 volts draws 10. Amperes of current. How much heat energy is delivered by the iron in 30 Seconds?
a) $3.0 \times 10^2 \text{ J}$ b) $3.6 \times 10^3 \text{ J}$ c) $1.2 \times 10^3 \text{ J}$ d) $3.6 \times 10^4 \text{ J}$
20. A radar gun can determine the speed of a moving automobile by measuring the difference in frequency between emitted and reflected radar waves. This process illustrates
a) Resonance b) Diffraction c) The Doppler effect d) Refraction

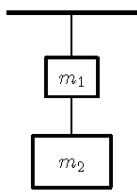
PART II – PHYSICS

21	A 70.-kilogram cyclist develops 210 watts of power while pedaling at a constant velocity of 7.0 meters per second east. What average force is exerted eastward on the bicycle to maintain this constant speed?						
(a)	490 N	(b)	3.0 N	(c)	30 N	(d)	1470 N
22	The gravitational potential energy, with respect to Earth, that is possessed by an object is dependent on						
(a)	Acceleration	(b)	Position	(c)	Momentum	(d)	Velocity
23	Which phenomenon provides evidence that light has a wave nature?						
(a)	Emission of light from an energy-level transition in a hydrogen atom	(b)	Diffraction of light passing through a narrow opening	(c)	Absorption of light by a black sheet of paper	(d)	Reflection of light from a mirror
24	When Earth and the Moon are separated by a distance of 3.84×10^8 meters, the magnitude of the gravitational force of attraction between them is 2.0×10^{20} newtons. What would be the magnitude of this gravitational force of attraction if Earth and the Moon were separated by a distance of 1.92×10^8 meters?						
(a)	5.0×10^{19} N	(b)	4.0×10^{20} N	(c)	2.0×10^{20} N	(d)	8.0×10^{20} N
25	The graph represents the motion of a car during a 6.0-second time interval. What is the total distance traveled by the car during this 6.0-second interval?			(d)			
(a)	60. m	(b)	20. m	(c)	30. m	(d)	40. m
26	A motorcycle being driven on a dirt path hits a rock. Its 60.-kilogram cyclist is projected over the handlebars at 20.0 meters per second into a haystack. If the cyclist is brought to rest in 0.50 second, the magnitude of the average force exerted on the cyclist by the haystack is						
(a)	6.0×10^1 N	(b)	5.9×10^2 N	(c)	1.2×10^3 N	(d)	2.4×10^3 N
27	Which combination of resistors has the <i>smallest</i> equivalent resistance?						
(a)		(b)		(c)		(d)	
28	A constant potential difference is applied across a variable resistor held at constant temperature. Which graph best represents the relationship between the resistance of the variable resistor and the current						
(a)		(b)		(c)		(d)	
29	The current traveling from the cathode to the screen in a television picture tube is 5.0×10^{-5} ampere. How many electrons strike the screen in 5.0 seconds?						
(a)	3.1×10^{24}	(b)	1.6×10^{15}	(c)	6.3×10^{18}	(d)	1.0×10^5
30	As a sound wave passes from water, where the speed is 1.49×10^3 meters per second, into air, the wave's speed						
(a)	Decreases and its frequency remains the same	(b)	Increases and its frequency remains the same	(c)	Remains the same and its frequency decreases	(d)	Remains the same and its frequency increases
31	The diagram below represents an electric circuit consisting of a 12-volt battery, a 3.0-ohm resistor, R_1 , and a variable resistor, R_2 . At what value must the variable resistor be set to produce a current of 1.0 ampere through R_1 ?			(d)			
(a)	6.0 Ω	(b)	3.0 Ω	(c)	9.0 Ω	(d)	12 Ω

32	A single vibratory disturbance moving through a medium is called						
(a)	A node	(b)	A standing wave	(c) An antinode	(d) A pulse		
33	A source of waves and an observer are moving relative to each other. The observer will detect a steadily increasing frequency if						
(a)	He moves toward the source at a constant speed.	(b)	The source moves away from him at a constant speed.	(c) He accelerates toward the source	(d) The source accelerates away from him		
34	A wave is diffracted as it passes through an opening in a barrier. The amount of diffraction that the wave undergoes depends on both						
(a)	Amplitude and frequency of the incident wave	(b)	Wavelength and speed of the incident wave	(c) Wavelength of the incident wave and the size of the opening	(d) Amplitude of the incident wave and the size of the opening		
35	The diagram on right represents two waves of equal amplitude and frequency approaching point <i>P</i> as they move through the same medium. As the two waves pass through each other, the medium at point <i>P</i> will						
(a)	Vibrate up and down	(b)	Vibrate into and out of the page	(c) Vibrate left and right	(d) Remain stationary		
36	A constant unbalanced force is applied to an object for a period of time. Which graph best represents the acceleration of the object as a function of elapsed time?						
(a)		(b)		(c)		(d)	
37	<p>The graph below represents the kinetic energy, gravitational potential energy, and total mechanical energy of a moving block.</p> <p style="text-align: center;">Energy vs. Distance Moved</p>  <p style="text-align: center;">Which best describes the motion of the block?</p>						
(a)	Accelerating on a flat horizontal.	(b)	Falling freely	(c) Sliding up a frictionless incline	(d) Being lifted at constant velocity		
38	Which graph best represents the relationship between the magnitude of the electric field strength, <i>E</i> , around a point charge and the distance, <i>r</i> , from the point charge?						
(a)		(b)		(c)		(d)	
39	The force required to start an object sliding across a uniform horizontal surface is larger than the force required to keep the object sliding at a constant velocity. The magnitudes of the required forces are different in these situations because the force of kinetic friction						
(a)	Is greater than the force of static friction.	(b)	Is less than the force of static friction.	(c) Increases as the speed of the object relative to the surface increases.	(d) Decreases as the speed of the object relative to the surface increases.		

40	A laser beam is directed at the surface of a smooth, calm pond as represented in the diagram below. Which organisms could be illuminated by the laser light?			
(a)	The bird and the fish.	(b) The crab and the seaweed.	(c) The bird and the seaweed.	(d) The crab and the fish.
41	An immersion heater has a resistance of 5.0 ohms while drawing a current of 3.0 amperes. How much electrical energy is delivered to the heater during 200 seconds of operation?			
(a)	$3.0 \times 10^3 \text{ J}$	(b) $9.0 \times 10^3 \text{ J}$	(c) $6.0 \times 10^3 \text{ J}$	(d) $1.5 \times 10^4 \text{ J}$
42	Ball A of mass 5.0 kilograms moving at 20. meters per second collides with ball B of unknown mass moving at 10 meters per second in the same direction. After the collision, ball A moves at 10 meters per second and ball B at 15 meters per second, both still in the same direction. What is the mass of ball B?			
(a)	6.0 kg	(b) 10.0 kg	(c) 2.0 kg	(d) 12.0 kg
43	Identical resistors (R) are connected across the same 12-volt battery. Which circuit uses the greatest power?			
(a)		(b) 	(c) 	(d) 
44	Which graph best represents the motion of an object that is not in equilibrium as it travels along a straight line?			
(a)		(b) 	(c) 	(d) 
45	Standing waves in water are produced most often by periodic water waves			
(a)	Being absorbed at the boundary with a new medium.	(b) Refracting at a boundary with a new medium.	(c) Diffracting around a barrier	(d) Reflecting from a barrier
46	A change in the speed of a wave as it enters a new medium produces a change in			
(a)	Frequency	(b) Wavelength	(c) Period	(d) Phase
47	Oil droplets may gain electrical charges as they are projected through a nozzle. Which quantity of charge is not possible on an oil droplet?			
(a)	$8.0 \times 10^{-19} \text{ C}$	(b) $3.2 \times 10^{-19} \text{ C}$	(c) $4.8 \times 10^{-19} \text{ C}$	(d) $2.6 \times 10^{-19} \text{ C}$
48	A 15.0-kilogram mass is moving at 7.50 m/s on a horizontal, frictionless surface. What is the total work that must be done on the mass to increase its speed to 11.5 m/s?			
(a)	120. J	(b) 570. J	(c) 422. J	(d) 992. J
49	A child throws a ball toward the front end of an approaching train. The collision between the ball and the train is perfectly elastic. Let v be the speed of the ball with respect to the train and V its speed with respect to the ground. If the labels “ i ” and “ f ” refer to those speeds just before and just after, respectively, the ball hits the train, then			
(a)	$v_i = v_f$ and $V_i < V_f$	(b) $v_i < v_f$ and $V_i < V_f$	(c) $v_i > v_f$ and V_i	(d) $v_i = v_f$ and $V_i > V_f$
50	A physics textbook of mass m rests flat on a horizontal table of mass M placed on the ground. Let $N_{a \rightarrow b}$ be the contact force exerted by body “a” on body “b”. According to Newton’s 3rd Law, which of the following is an action-reaction pair of forces?			
(a)	mg and $N_{\text{table} \rightarrow \text{book}}$	$(m + M)g$ and $N_{\text{table} \rightarrow \text{book}}$	$N_{\text{ground} \rightarrow \text{table}}$ and $Mg + N_{\text{book} \rightarrow \text{table}}$	$N_{\text{ground} \rightarrow \text{table}}$ and $N_{\text{table} \rightarrow \text{ground}}$
51	A simple pendulum of length L with a bob of mass m is taken into Earth orbit on the International Space Station. Its frequency of oscillation with respect to that on the ground is			
(a)	greater	(b) smaller but non-	(c) the same	(d) zero

52	A projectile is launched with an initial velocity v_i , with v_{ix} and v_{iy} the horizontal and vertical velocity components, respectively. When is there a point on its trajectory after launch where its velocity is						
(a)	Always	(b)	Only if $v_{ix} \neq 0$ and v_{iy} points upward	(c)	Only if $v_{ix} \neq 0$	(d)	Always, except if $v_{ix} = 0$
53	As more and more negative electric charge is being brought to a conducting sphere, inside the sphere						
(a)	The electric field and potential increase.	(b)	The electric field stays constant and the potential.	(c)	The electric field stays constant and the potential.	(d)	The electric field increases and the potential decreases.
54	A string of length L is composed of two segments of equal length. One segment has linear mass density μ_1 and the other $\mu_2 \neq \mu_1$. One segment is tied to a wall, and the string is stretched by a force, applied to the other segment, which is much greater than the total weight of the string. If T_i is the tension in the i th segment, and v_i the speed of a transverse wave propagating along that segment						
(a)	$v_1 = v_2$ & $T_1 = T_2$	(b)	$v_1 \neq v_2$ & $T_1 = T_2$	(c)	$v_1 = v_2$ & $T_1 \neq T_2$	(d)	$v_1 \neq v_2$ & $T_1 \neq T_2$
55	A perfectly straight portion of a uniform rope has mass M and length L . At end A of the segment, the tension in the rope is T_A ; at end B it is $T_B > T_A$. The tension in the rope at a distance $L/5$ from end A is						
(a)	$T_B - T_A$	(b)	$(T_A + T_B)/5$	(c)	$(4T_A + T_B)/5$	(d)	$(T_A - T_B)/5$
56	Two spheres are identical except that sphere A is white whereas sphere B is black. After they have been in thermal contact long enough with each other and their surroundings, in the visible range						
(a)	A radiates less than B.	(b)	Both emit the same amount of radiation.	(c)	A radiates more than B.	(d)	A radiates more than B only if its temperature is high enough.
57	Why does a raindrop fall with near-constant speed during the later stages of its descent?						
(a)	The gravitational force is constant.	(b)	Gravity cannot increase the speed of a falling object to more than 9.8 ms^{-1}	(c)	Air resistance just balances the force of gravity.	(d)	The force of gravity is negligible for objects as small as a raindrop.
58	A glass-walled elevator is moving upwards with constant acceleration. At some point in the elevator's motion, a bolt breaks loose and drops from the ceiling. What is the motion of the bolt as seen by an external observer (i.e. one located outside the elevator)?						
(a)	The bolt moves upwards at a constant speed.	(b)	The bolt initially moves upwards, then slows, reverses direction and moves downwards.	(c)	The bolt appears to remain stationary.	(d)	The bolt immediately moves downwards, accelerating as it goes.
59	The Earth and the Moon both exert gravitational forces on objects in their vicinity. Imagine a line joining the Earth to the Moon, and extending to either side, as shown below (not to scale). Consider placing an object along this line. Where along this line is the net gravitational force on the object due to the Earth and the Moon equal to zero.						
							
(a)	On the far side of the Earth from the Moon.	(b)	Halfway between the Earth and the Moon.	(c)	Between the Earth and the Moon, but closer to the Earth than to the Moon.	(d)	Between the Earth and the Moon, but closer to the Moon than to the Earth.
60	A ball is held at a height H above a floor, as sketched in the diagram on the right. It is then released and falls to the floor. If air resistance can be ignored, which of the four graphs below (labelled a to d) correctly gives the mechanical energy E_{mech} of the Earth-ball system as a function of the altitude y of the ball?						
							
(a)		(b)		(c)		(d)	

61	Some students are doing an experiment to calculate the spring constant of a particular spring. As part of this experiment, they suspend an object from the spring, pull it downwards, and let it go. The object then oscillates up and down, with a period of about 2 seconds. The students use a stopwatch to measure the period of oscillation. The best way to get an accurate and precise measurement of the period would be to:						
(a)	Measure the time taken for a single oscillation 10 times, and average the results.	(b)	Measure the time taken for a single oscillation 10 times, and average the results. Repeat this measurement three times, and average the results.	(c)	Measure the time taken for 10 oscillations, and divide by 10. Repeat this measurement three times, and average the results.	(d)	All of the methods above are equivalent, and will result in the same precision in the measurement of the period of oscillation.
62	A roller-coaster car is full of water, and is moving at constant velocity along a frictionless horizontal track. Someone removes a plug in the bottom of the floor, allowing the water to drain out. Ignoring air resistance, as the water drains out the car will:						
(a)	Slow down	(b)	Continue to move at constant velocity	(c)	Speed up	(d)	Initially speed up, then slow down
63	The velocity of a particle moving along the x-axis changes from v_i to v_f . For which of these values of v_i and v_f does the particle's kinetic energy increase the most?						
(a)	$v_i = 5 \text{ m/s}$ & $v_f = 2 \text{ m/s}$	(b)	$v_i = 5 \text{ m/s}$ & $v_f = -2 \text{ m/s}$	(c)	$v_i = -5 \text{ m/s}$ & $v_f = -2 \text{ m/s}$	(d)	$v_i = 2 \text{ m/s}$ & $v_f = -5 \text{ m/s}$
64	An introductory physics student, elated by a first semester grade, celebrates by dropping a textbook from a balcony into a deep layer of soft snow which is 3.00 m below. Upon hitting the snow the book sinks a further 1.00 m into it before coming to a stop. The mass of the book is 5.0 kg. Assuming a constant retarding force, what is the approximate value of force from the snow on the book?						
(a)	100 N	(b)	120 N	(c)	150 N	(d)	200 N
65	A mass on a frictionless table is attached to the midpoint of an originally unstretched spring fixed at the ends. If the mass is displaced a distance A parallel to the table surface but perpendicular to the spring, it exhibits oscillations. The period T of the oscillations						
(a)	Does not depend on A	(b)	Increases as A increases, approaching a fixed value	(c)	Decreases as A increases, approaching a fixed value.	(d)	Is approximately constant for small values of A, then increases without bound.
66	Kepler's Laws state that I. the orbits of planets are elliptical with one focus at the sun, II. a line connecting the sun and a planet sweeps out equal areas in equal times, and III. the square of the period of a planet's orbit is proportional to the cube of its semimajor axis. Which of these laws would remain true if the force of gravity were proportional to $1/r^3$ rather than $1/r^2$?						
(a)	Only I	(b)	Only II	(c)	Only III	(d)	Both II and III
67	Two blocks are suspended by two massless elastic strings to the ceiling as shown in the figure. The masses of the upper and lower block are $m_1 = 2 \text{ kg}$ and $m_2 = 4 \text{ kg}$, respectively. If the upper string is suddenly cut just above the top block what are the accelerations of the two blocks at the moment when the top block begins to fall?						
							
(a)	Upper: 10 m/s^2 ; lower: 0	(b)	Upper: 10 m/s^2 ; lower: 10 m/s^2	(c)	Upper: 20 m/s^2 ; lower: 10 m/s^2	(d)	Upper: 30 m/s^2 ; lower: 0
68	A ball rolls from the back of a large truck traveling 10.0 m/s to the right. The ball is traveling horizontally at 8.0 m/s to the left relative to an observer in the truck. The ball lands on the roadway 1.25 m below its starting level. How far behind the truck does it land?						
(a)	0.50 m	(b)	1.0 m	(c)	4.0 m	(d)	5.0 m

69	A block floats partially submerged in a container of liquid. When the entire container is accelerated upward, which of the following happens? Assume that both the liquid and the block are incompressible.						
(a)	The block descends down lower into the liquid.	(b)	The block ascends up higher in the liquid.	(c)	The block does not ascend nor descend in the liquid.	(d)	The answer depends on the rate of change of the acceleration.
70	An object is released from rest and falls a distance h during the first second of time. How far will it fall during the next second of time?						
(a)	h	(b)	$2h$	(c)	$3h$	(d)	$4h$

Part III: Physics-Descriptive Questions [30 Marks]

Question No 1: A 0.20 kg mass is attached to the lower end of a helical spring which is fixed at its upper end. The vertical spring is extended by 0.16 m in equilibrium. Determine:

- a) The change in gravitational potential energy of the mass due to spring's extension.
- b) The elastic energy stored in the spring.
- c) Why do the magnitude of (i) and (ii) differ?

The mass is pulled down a further distance of 0.07 m and released.

- d) What is its kinetic energy when passing through the equilibrium position?
- e) What is its period of oscillation?
- f) If the upper end of the spring is released, describe the motion of the mass and the spring?

(10)

Question No 2:

- a) Assuming the planets are in circular motion around the Sun, with radius R and period T , use the data in Table 2.1 to test, graphically, the hypothesis that T is proportional to R^α , where α is a constant. Obtain from the graph:
 - i) A value for α and give its accuracy.
 - ii) The constant of proportionality in SI units.

PLANET	$R/10^8$ km	T/days
Earth	1.49	365
Mars	2.28	687
Jupiter	7.78	4333
Uranus	28.7	30690

Table 2.1

- b)
 - i) Derive, using mechanics, the relationship between T and R in terms of the mass of the Sun, M_S .
 - ii) Determine M_S using the data in (a).
 - iii) The distance of the Moon from the Earth is 3.8×10^5 km and its period is 27.3 days. Deduce the ratio (M_S/M_E) , where M_E is the mass of the Earth.

(10+10)

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