



JINNAH UNIVERSITY FOR WOMEN

First Terminal Examination 2018 • Course Incharge Prof. Dr. Syed Arif Kamal

Department Mathematics • Class BS-IV/MSc (Final) • Date May 24, 2018

Course Title Biomathematics • Course Code MAT 4031/MAT 621

Time Allowed 2 hours 30 minutes • Max Marks 60

Note: Attempt all questions. Marks of each question are shown in front of that question.

Question No.	Question Text	Marks Allocated														
01	In the following table we have dates of check up for a child. Compute her age at each check up in decimal form, using the date of birth given (note that each month has different number of days, leap year has 29 days in February): <table><tr><th>ZHZ</th><th>Year-Month-Day</th></tr><tr><td>Date of Birth</td><td>2005-06-16</td></tr><tr><td>First Check-up</td><td>2011-05-04</td></tr><tr><td>Second Check-up</td><td>2012-03-20</td></tr><tr><td>Third Check-up</td><td>2012-05-13</td></tr><tr><td>Fourth Check-up</td><td>2013-06-02</td></tr><tr><td>Fifth Check-up</td><td>2014-11-23</td></tr></table>	ZHZ	Year-Month-Day	Date of Birth	2005-06-16	First Check-up	2011-05-04	Second Check-up	2012-03-20	Third Check-up	2012-05-13	Fourth Check-up	2013-06-02	Fifth Check-up	2014-11-23	10
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02	List the mathematical concepts and the senses (out of 5 senses) used in physical-examination techniques (inspection, auscultation,).	10														
03	(a) List the pedagogical opportunities offered by the activity of measurement of height in the domains of biology, chemistry, engineering, health and safety, mathematics, physics and Quranic studies. (b) Prove $\mu = \mu_a + \mu_b - \mu_{a+b}$, where μ is net mass (mass with zero clothing on), μ_a mass with one set of clothing worn, μ_b mass with the other set of clothing worn and μ_{a+b} mass with both sets of clothing worn (this formula could be used to compute net mass without asking the subject to disrobe completely). (c) Describe an experiment (and the associated mathematical framework) to verify this formula.	14 10 06														
04	Write short note on any one of the following: (a) Body-mass index (<i>BMI</i>) (b) Scoliosis	10														



SOLUTION

Question 1

In the following table we have dates of check up for a child. Compute her age at each check up in decimal form, using the date of birth given (note that each month has different number of days, leap year has 29 days in February):

ZHZ	Year-Month-Day
Date of Birth	2005-06-16
First Check-up	2011-05-04
Second Check-up	2012-03-20
Third Check-up	2012-05-13
Fourth Check-up	2013-06-02
Fifth Check-up	2014-11-23

Solution 1

Using data from Table 1 (modified from Table 4 of J29.pdf, p. 93), decimal dates for ZHZ are computed for non-leap years, 2005, 2011, 2013 and 2014 as well as leap year 2012. These are listed in Table 2:

Table 1. Cumulative Days in a Year

#	Months	Non-leap Year		Leap Year	
		Days	Cumulative Days	Days	Cumulative Days
01	January	31	31	31	31
02	February	28	59	29	60
03	March	31	90	31	91
04	April	30	120	30	121
05	May	31	151	31	152
06	June	30	181	30	182
07	July	31	212	31	213
08	August	31	243	31	244
09	September	30	273	30	274
10	October	31	304	31	305
11	November	30	334	30	335
12	December	31	365	31	366

$$\text{Date of Birth} = \text{YYYY} + \frac{\text{Days}(\text{MM} - 1) + \text{Days}(\text{DD})}{365} = 2005 + \frac{151 + 16}{365} = 2005.45753442465753425$$

$$\text{First Checkup} = \text{YYYY} + \frac{\text{Days}(\text{MM} - 1) + \text{Days}(\text{DD})}{365} = 2011 + \frac{120 + 04}{365} = 2011.3397260273972603$$

$$\text{Second Checkup} = \text{YYYY} + \frac{\text{Days}(\text{MM} - 1) + \text{Days}(\text{DD})}{365} = 2012 + \frac{60 + 20}{366} = 2012.2185792349726776$$

$$\text{Third Checkup} = \text{YYYY} + \frac{\text{Days}(\text{MM} - 1) + \text{Days}(\text{DD})}{365} = 2012 + \frac{121 + 13}{366} = 2012.3661202185792350$$

$$\text{Fourth Checkup} = \text{YYYY} + \frac{\text{Days}(\text{MM} - 1) + \text{Days}(\text{DD})}{365} = 2013 + \frac{151 + 02}{365} = 2013.4191780821917808$$

$$\text{Fifth Checkup} = \text{YYYY} + \frac{\text{Days}(\text{MM} - 1) + \text{Days}(\text{DD})}{365} = 2014 + \frac{304 + 23}{365} = 2014.8958904109589011$$

Table 2. Decimal ages for 5 checkups of ZHZ (case reported in J38 and J45)

Checkup	Dec. Date of Birth	Dec. Date of Check up	Dec. Age (year)
1 st	2005.45753442465753425	2011.3397260273972603	5.88219780821917800
2 nd	2005.45753442465753425	2012.2185792349726776	6.761044988397335100
3 rd	2005.45753442465753425	2012.3661202185792350	6.908585972003825000
4 th	2005.45753442465753425	2013.4191780821917808	7.96164383561643830
5 th	2005.45753442465753425	2014.8958904109589011	9.43835616438356162



Question 2

List the mathematical concepts and the senses (out of 5 senses) used in physical-examination techniques (inspection, auscultation,).

Solution 1

The mathematical concepts and the senses (out of 5 senses) used in physical-examination techniques are listed in Table 3:

Table 3. Mathematical concepts and physical senses employed in physical-examination techniques

Physical-Examination Technique	Mathematical Concept	Sense
Inspection	Symmetry	Sight
Auscultation	Inverse problem	Hearing
Percussion	Inverse problem	Hearing, touch
Palpation	Properties of material, body temperature	Touch
Olfaction	Inverse problem	Smell

Question 3a

List the pedagogical opportunities offered by the activity of measurement of height in the domains of biology, chemistry, engineering, health and safety, mathematics, physics and Quranic studies.

Solution 3a

Figure 1 lists pedagogical opportunities offered by the activity of measurement of height in the domains of biology, chemistry, engineering, health and safety, mathematics, physics and Quranic studies.

Biology	The metabolism of food
Chemistry	The process of conversion of food resulting in <i>tissue synthesis</i> (the phenomenon of height gain)
Engineering	Level surface needed, mounting of engineering tape (vertical mounting checked by plumb line)
Health and Safety	Evaluating nutritional status, failure to gain height may be a signal to some physical problem (failure-to-grow); failure to gain height and achieve developmental milestones may indicate a much deeper problem (failure-to-thrive) — pediatrician should look for indications of abuse (neglect, peer pressure/bullying, verbal, physical, sexual) in this situation
Mathematics	Significance of serial measurements, plotting of graph, computation of slope, time-series concept, prediction of adult height, comparison with cut-off height for armed-forces career
Physics	Techniques of measurements, achieving reproducibility, applying equal weight on both feet
Quranic Studies	The Holy Quran (sacred book of Muslims) mentions appointment of Tālōt as king over Israelites (verse 247, chapter 2, <i>Suratul-Baqara</i>). It is mentioned that Samuel (peace be upon him) had a rod. It was told to Israelites that their king would be as tall as the length of rod — comparison of height with agreed-upon standard

Figure 1. Pedagogical opportunities offered by the activity of measurement of height

Question 3b

Prove $\mu = \mu_a + \mu_b - \mu_{a+b}$, where μ is net mass (mass with zero clothing on), μ_a is with one set of clothing worn, μ_b mass with the other set of clothing worn and μ_{a+b} mass with both sets of clothing worn (this formula could be used to compute net mass without asking the subject to disrobe completely).

Solution 3b

We have $\mu_a = \mu + a$, $\mu_b = \mu + b$, $\mu_{a+b} = \mu + (a + b)$, where a is mass of the first set of clothing and b is mass of the second set of clothing. Now, $\mu_a + \mu_b - \mu_{a+b} = (\mu + a) + (\mu + b) - \mu - (a + b) = \mu$, which completes the proof.



Question 3c

Describe an experiment (and the associated mathematical framework) to verify this formula.

Solution 3c

Let $\mu = A\mu_a + B\mu_b + C\mu_{a+b}$. Fit a regression plane on mass data collected on 100 children, with the children in dress code $\frac{0}{0.5}(\mu)$, with one set of clothing worn (μ_a), with another set of clothing worn (μ_b), and with both sets of clothing worn (μ_{a+b}). Minimize to determine the values of A , B and C . If A comes out to be close to +1, B to +1 and C to -1, the formula given in 3b is valid.

Question 4

Write short note on any one of the following:

- (a) Body-Mass Index (BMI)
- (b) Scoliosis

Solution 4

(a) *Body-Mass Index (BMI)*

BMI is short form of *Body-Mass Index*. This index is, basically, used to determine status of wasting or obesity (cf. Figure 2). *BMI* of a person is computed by dividing net mass (mass with zero clothing on), μ , of an individual (in *kg*: kilogram) by square of height of that person, h (in *m*: meter)

$$BMI = \frac{\mu}{h^2}$$

BMI is reported in kg/m^2 and could be interpreted on the basis of Table 4 for adult population.

Table 4. WHO classification of body-mass index, applicable to adult population

Descriptive Label	BMI Values
Excessively Wasted	$BMI < 15$
Severely Wasted	$15 \leq BMI < 16$
Wasted	$16 \leq BMI < 18.5$
Normal	$18.5 \leq BMI < 25$
Obese	$25 \leq BMI < 30$
Moderately Obese	$30 \leq BMI < 35$
Severely Obese	$35 \leq BMI < 40$
Excessively Obese	$BMI \geq 40$

During 1960s, while exploring various indices dealing with mass (weight) and height, it was observed that in adults, normal body mass (*kg*) was proportional to the square of height (*m*), as proposed by Adolphe Quetelet (1796-1874), Belgian mathematician, astronomer and statistician, in 1832, recognized in the then small circle of experts as the 'Quetelet Index'. In 1972, Ancel Keys (1904-2004) renamed it as 'Body-Mass Index'. By that time, many ratios of height and mass were suggested, *e. g.* Ponderal Index, which is mass (in *kg*) divided by cube of height (in *m*). Keys made a comparative study of different indices of obesity and declared *BMI* to be the best predictor of average body-fat percentage. Calling *BMI* as ratio of mass to square of height is not appropriate, as ratio is dimensionless, obtained between quantities having the same dimension. Kamal and Jamil introduced 'estimated-adult *BMI*' in 2012 (useful to get a snapshot of status of obesity of children, when they are fully grown) and defined '*BMI* ratio' as *BMI* divided by unit *BMI* ($1 kg/m^2$) in a paper published in 2014. A much better word is 'index' to refer to *BMI*. Some of the weak points of *BMI* are that it fails to consider factors like body-frame size and muscularity, been based on wrong assumptions about fat- and lean-mass distribution in the body. As the person becomes older, height is decreased because of curvature of bones, which results in *BMI* increase, in spite of the fact that mass remains unchanged. *BMI*, also, is unable create a universal threshold for conditions of overweight and underweight, due to inter- and intra-region variations in body compositions. This variation appears when there are different ethnic groups present within the same region. The performance of *BMI* was assessed in 2010 by Okorodudu and co-workers. According to their analysis *BMI* has a high specificity but a low



sensitivity to identify adiposity. In a 2011 paper, Zheng and coworkers studied relationship of *BMI* with death risk in a large Asian population. For children, *BMI* range, used for estimating statuses for adults, cannot be used — *BMI* tables are needed for interpretation. In a paper published in 2001, Karlberg and coworkers gave *BMI* reference values (mean and standard deviation) for Swedish children. In a paper published in 2008, Ramzan and coworkers studied *BMI* of children of Dera Ismail Khan (a city located in KP Province of Pakistan). In a series of papers published during the period 1994-2002, Guo and coworkers discussed predictive value of childhood *BMI* to indicate overweight and obesity in adulthood. *BMI*, however, does not seem to be ideal index as indicator of obesity or wasting, since the underlying relationship between *BMI* cut-off points and their clinical implications as well as health risks are not studied well.

(b) *Scoliosis*

Scoliosis, lateral curvature of the spinal column, effects children in their growth period. If recognized early the deformity may be treated by a combination of exercises and braces. However, if it reaches advanced stage it may disfigure the body, cosmetically, and may affect vital organs, like heart and lungs. At this stage, the only recourse is major spinal surgery. Since spinal column is the site of many nerves, which control our motor system, any damage to these may cripple the patient. Professor Dr. H. Neugebauer of Orthopadisches Krankenhaus Gersthof, Vienna, Austria, a well-known Orthopedic Surgeon and host of an Orthopedic Conference in 1988, mentioned that he operated on a girl for scoliosis and she was paralyzed from the waist down. The spinal column of girls is more flexible than that of boys. The incidence of scoliosis is also in the ratio of 5 to 1 in girls as compared to that in boys according to studies conducted in the West. Scoliosis has no symptoms and is recognized, only, by the deformity it produces in the body. During the school-going period make sure that the children do not carry unnecessary books in their school bags. The school bags should not be carried on one side. They should be worn properly on the back exerting load evenly on both sides. The best way to avoid these complications and major surgery is to monitor young children from age 7 years onward for the presence of curvatures of spinal column by conducting a 2-minute orthopedic examination with the child completely undressed except short underpants. The parents may help recognize many cases early enough to avoid surgery by keeping a watchful eye on their children between the ages of 5-10 years. Since 1982, spinal column is visualized in three dimensions and a number of models have been developed to understand the disease by Pakistani researchers.