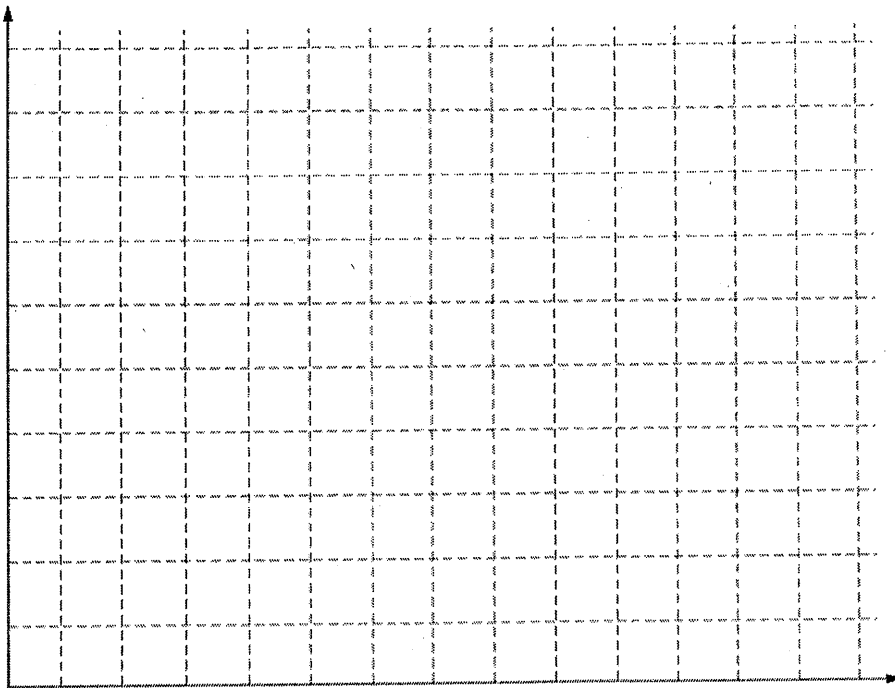


2003 AP[®] ENVIRONMENTAL SCIENCE FREE-RESPONSE QUESTIONS

2. A certain fictional country called Industria is tracking its population data. In 1855, the first year vital statistics were reported for the country, the population was 1.6 million, with a crude birth rate of 43 per 1,000. At that time the population of Industria was growing quite slowly, because of the high death rate of 41 per 1,000. In 1875 the population began to grow very rapidly as the birth rate remained at its 1855 level, while the crude death rate dropped dramatically to 20 per 1,000. Population growth continued to increase in the small country into the late 1800's, even though birth rates began to decline slowly.

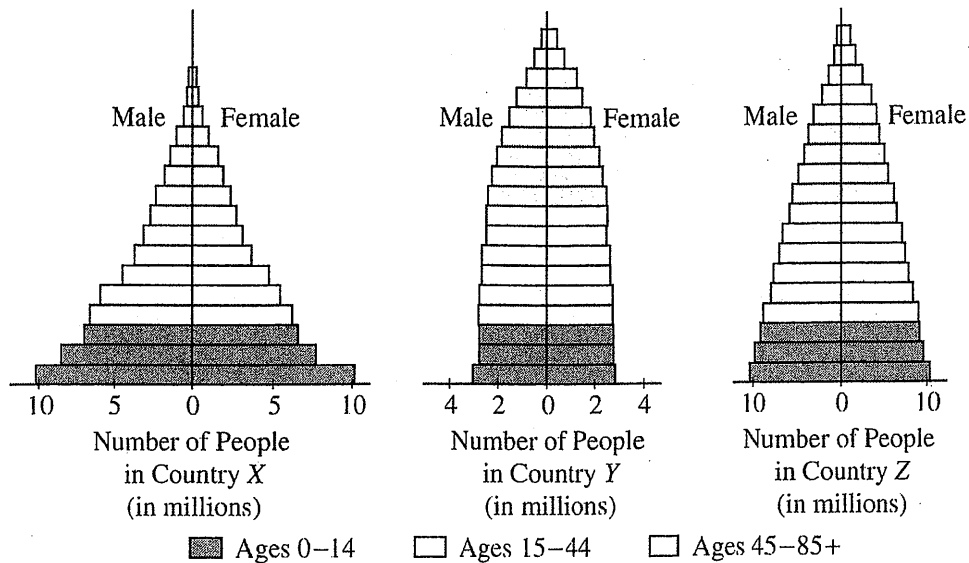
In 1895 the crude birth rate had dropped to 37, and the death rate to 12 per 1,000. In that year (1895) a complete census revealed that the population of Industria had grown to 2.5 million. By 1950 population growth gradually began to decline as the death rate remained at its 1895 level, while the birth rate continued to decline to 22 per 1,000. In 1977 vital statistics revealed that the death rate was 10 per 1,000, and that population growth had slowed even more to an annual rate of 0.4%. By 1990 Industria had reduced its birth rate to that of its now constant, low death rate, and the population transition was complete.

- (a) On the axes below, plot the crude birth-rate data from 1855 to 1990. Now plot the crude death-rate data on the same axes. Clearly label the axes and the curves.



- (b) What was the annual growth rate of Industria in 1950? What was the birth rate in Industria in 1977?
- (c) Indicate TWO factors that might have accounted for the rapid decline in the death rate in Industria between 1855 and 1895. Indicate one specific reason why the birth rate might have been so high in 1855 and was so slow to decrease between 1855 and 1950.
- (d) Determine what the population size of Industria would have been in 1951 if the population had continued to grow at the annual rate of growth recorded for Industria in 1895.

2000 AP® ENVIRONMENTAL SCIENCE FREE-RESPONSE QUESTIONS



4. The figures above show the age structures of human populations in three countries, X, Y and Z.
- (a) Which of the three countries has the largest rate of population growth? Which has the smallest rate? Explain.
 - (b) Compare the infant mortality rates that are likely in Countries X and Y. Explain your reasoning.
 - (c) Describe the changes in both the birth rate and the death rate for a country making the transition from a preindustrial society to an industrial society.
 - (d) Describe one incentive that the government of a country could offer its citizens that would favor a reduction in the growth rate of its population. Explain how this incentive would work, and describe one possible drawback.

END OF EXAMINATION

Question 2

(a) On the axes below, plot the crude birth rate data from 1855 to 1990. Now plot the crude death-rate data on the same axes. Clearly label the axes and the curves. (3 points total)

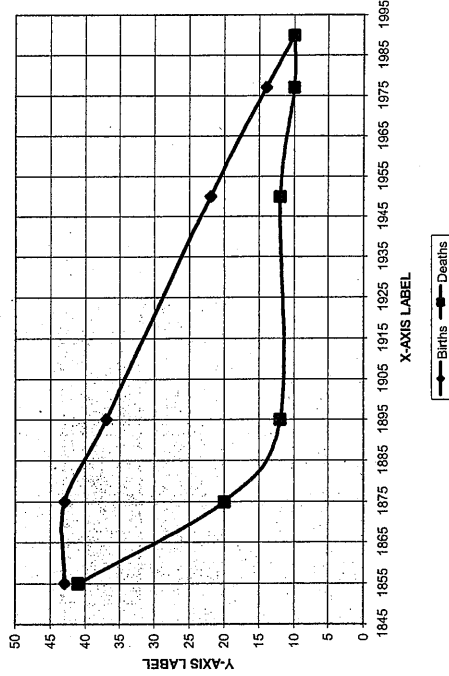
- 1 point for correctly scaling and labeling axes: scales must include all provided data from 1855-1990 scales used may be different than what appears on the graph below – students may, for example, label the y-axis in increments of 10 from 0 to 100 or the x-axis in increments of 20 years
- Acceptable x-axis labels: year, date, or time
 - Acceptable y-axis labels: births & deaths per 1,000, birth & death rate (percent, people per 1,000, rate per 1,000 only if curves are clearly labeled)

1 point for correctly labeling and plotting crude birth rate

- 5 data points must be clearly shown on the graph (not including the 1977 data point)
- 1977 data point is optional since it was not provided in this part, but is requested in part (b)
- If the 1977 data point is present, it must be plotted correctly at $y = 14$

1 point for correctly labeling and plotting crude death rate

- 6 data points must be clearly shown on the graph



Note: Since the student is not instructed to plot a curve of best fit, either a smoothed curve or a straight-line curve is acceptable; however, if the curve(s) does not pass through all data points, 0 points for labeling curve(s) are awarded. If the student truncates the x-axis or the y-axis, the data lines must also be truncated accordingly.

Question 2 (cont'd.)

(b) What was the annual growth rate of Austria in 1950? What was the birth rate in Austria in 1977? (2 points total)

1 point for correct annual growth rate in 1950

Student shows calculations using the formula: $r = b - d$

$$\frac{22}{1000} - \frac{12}{1000} = \frac{10}{1000}$$

or, $2.2\% - 1.2\% = 1\%$ or, $0.022 - 0.012 = 0.01$ or, calculations are stated in words

OR,

student shows calculations using the formula: $r = \frac{\text{CBR} - \text{CDR}}{10}$

$$\frac{22\% - 12\%}{10} = 1\% \text{ or, calculations are stated in words}$$

1 point for the birth rate in 1977, which may be determined graphically, by calculations, or as presented in words

If determined graphically, the 1977 data point must be marked on the curve (a range of 12-17 per 1,000 is acceptable) OR, the student must state that the value was obtained from the graph and the value must have been correctly interpolated. The answer must be in the same units of measurement as the axis unless clearly converted by the student.

Student shows calculations using the formula $r = b - d$ (which must be shown or presented in words)

$$0.4\% = b - 1.0\% \Rightarrow 1.4\% = b \text{ or, } \frac{4}{1000} = b - \frac{10}{1000} \Rightarrow \frac{14}{1000} = b$$

or, $0.004 = b - 0.01 \Rightarrow 0.014 = b$ or, calculations are stated in words

OR,

student shows calculations using the formula $r = \frac{\text{CBR} - \text{CDR}}{10}$

$$0.4 = \frac{\text{CBR} - 10}{10} \Rightarrow 14 = \text{CBR} \text{ or, calculations stated in words}$$

Note: Other algebraic formulas, or derivatives of those above, may be used provided all work is shown.

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Question 2 (cont'd.)

- (c) Indicate TWO factors that might have accounted for the rapid decline in the death rate in Austria between 1855 and 1895. Indicate one specific reason why the birth rate might have been so high in 1855 and was so slow to decrease between 1855 and 1950. (4 points total)

1 point each for identifying two factors that might have accounted for a rapid decline in the death rate. Only the first two factors provided are considered.

Acceptable factors for rapid decline in death rate include:

- Improved medical care (antibiotics not accepted for given time period)
- Improved sanitation
- Improved personal hygiene
- Improved water supply
- Improved food or nutrition
- Improved agriculture or food production
- Improved food preservation
- Improved transportation to deliver food or to provide medical services
- Improved prenatal or neonatal care
- Cessation of military conflict

1 point for indicating one specific reason why birth rate was so high

Acceptable reasons for high birth rate include:

- To compensate for high infant mortality
- To assure care for aging parents (including reference to lack of institutionalized social security programs)
- To provide a labor force
- Cultural/religious practices that prohibited birth control
- Cultural/religious practices that favored large families
- Lack of contraceptives (not general statements about birth control)
- Lack of education about family planning
- Lack of women's rights

1 point for indicating why birth rate was so slow to decrease

Acceptable reasons for slow decrease include:

- Cultural/religious practices that prohibited birth control took time to change
- Cultural/religious practices that favored large families took time to change
- Immigration of women of child-bearing age
- Changing the status of women was slow to gain broad acceptance
- Educational opportunities for women were slow to appear
- Employment opportunities for women were slow to appear
- Slow advances/technological production relating to birth control resulted in a slow decline
- Slow implementation of government policies to reduce the need for children to provide support for their parents in their later years (eg. social security, health care, pensions, etc.)

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Question 2 (cont'd.)

- (d) Determine what the population size of Austria would have been in 1951 if the population had continued to grow at the annual rate of growth for Austria in 1895. (1 point total)

1 point for correctly calculating the population size in 1951

Student shows calculations using the Rule of 70

$$70/2.5 = 28 \text{ years}$$

$$1951 - 1895 = 56 \text{ years}$$

$$56 \text{ years} / 28 \text{ years} = 2 \text{ doublings}$$

$$2.5 \times 10^6 \times 2 = 5.0 \times 10^6 \Rightarrow 5.0 \times 10^6 \times 2 = 10 \times 10^6$$

$$\text{or, } 2,500,000 \times 2 = 5,000,000 \Rightarrow 5,000,000 \times 2 = 10,000,000 \text{ or, calculations are stated in words}$$

Alternate Solutions:

1 point for correct set-up using the formulas: $N_t = N_0 e^{(r \cdot t)}$, $N_t = N_0(1 + r)^t$, or $P = A_0 e^{kt}$, even if the equation is not solved, provided that all specific values, namely N_0 or A_0 , r or k , and t are correctly inserted into the equation and derivation of "r" (which is 56) is provided

Note: If a student recognizes that $0.025 \times 56 = 1.4$, and that $e^{(1.4)}$ or $2.72^{(1.4)}$ is approximately 4, and solved the equation as approximately 10×10^6 or 10,000,000, the point is awarded.

Question 4 Scoring Guide

(a) Comparing Population Growth Rates (3 POINTS MAXIMUM)

- 1 point earned for naming *X* as the country with the largest rate of population growth
- 1 point earned for naming *Y* as the country with the smallest growth/replacement level fertility
- 1 point earned for a statement explaining why country *X* has the largest growth rate and/or country *Y* has the smallest growth rate (only first explanation is graded)

Example: A relatively large segment of the population of country *X* is currently in the prereproductive/reproductive years and will soon begin having children (giving the population momentum). In contrast, the prereproductive cohorts in country *Y* are about equal in size to the reproductive and postreproductive cohorts. (Country *Y* exhibits zero population growth/reaches recruitment.)

Notes of things to look for:

- o Broad base and pyramid shape indicative of large rate of population growth (population momentum, reproduction, etc.)
- o Compare cohort ages of the lower cohorts (must include prereproductive/reproductive or population momentum idea)
- o Mere description of the histogram itself earns no credit

(b) Infant Mortality Rates (2 POINTS MAXIMUM)

1 point earned for stating that country *X* has a higher infant mortality rate than country *Y*, or that country *Y* has a lower infant mortality rate than country *X*.

1 point earned for explanation

Examples of accepted explanations:

- o Larger drop in population from one cohort to the next in bottom of histogram of country *X*
- o Little change in cohorts on histogram of country *Y*
- o Country *Y* probably is an industrialized/developed country (MDC), which usually has a lower infant mortality rate
- o Country *X* probably is an unindustrialized/developing country (LDC), which usually has a higher infant mortality rate
- o Infant mortality is lower in country *Y* due to, for example,
 - uncontaminated drinking water
 - better nutrition
 - better health care
 - education of women
- o Infant mortality higher in country *X* due to, for example,
 - contaminated drinking water
 - poor nutrition
 - poor health care
 - few or no educational opportunities for women

(c) Changes in Birth and Death Rates During Transition (3 POINTS MAXIMUM)

- 1 point earned for *preindustrial phase* (term not necessary): initially birth rate and death rate are both high
- 1 point earned for *transition phase*: birth rate remains high, death rate declines (because of better health care, etc.)
- 1 point earned for *industrial phase*: birth rate declines and approaches death rate (mention of postindustrial phase with explanation is acceptable)

(d) Government Incentives (3 POINTS MAXIMUM)

1 point earned for describing a government incentive to reduce population growth rate (only first incentive given is graded)

Examples of Incentives Accepted:

- o Free/more accessible/government-subsidized family planning -- must be linked to specific example, such as: free clinical services like birth control, free education about birth control, birth spacing, etc.
- o Economic rewards or penalties -- must be linked to specific example, such as:
 - payment for sterilization
 - eliminating income tax deductions for more than one child
 - free health-care benefits for families with 0-1 children
 - free higher education for women/child of single-child family
 - increased social security or pension benefits for couples with 0-1 children
 - better job opportunities for women/couples with 0-1 children
 - monetary bonus at end of year if only have 0-1 children
 - giving free counseling to teenagers that have had a child
 - government subsidized housing if have 0-1 children
 - bonus at end of year if woman remains under single-child limit
 - couples pay a tax for each child after the first one
 - other logical methods of negative economic incentives or rewards.
- o Raising legal marriage age
- o Specific examples with explanation (e.g., China)
 - paid leave to women for fertility operations
 - monthly subsidy to single-child families
 - job priorities for only children
 - housing preferences for single-child families
 - additional food rations for one-child families
 - monetary compensation for single-child families

Examples of Incentives NOT Accepted:

- o Decrease immigration -- legal and/or illegal. (Because the question refers to current citizens of a country. However, arguments that *definitely* link a government plan to reduce immigration through incentives to citizens, such as rewards for reporting illegal immigrant workers, are accepted.)

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(d) *(continued)*

1 point earned for explaining how the given incentive works to reduce growth rate of population

Examples of Explanations Accepted:

- Government provides free education for mother of 0-1 children. This enables the mother to get a better job and make more money. Studies show as women have higher education and better jobs, they tend to have fewer children, thus lowering the population growth rate.
- Government will give free health care to families of 0-1 children. They can then get the necessary medical care to keep that child alive and healthy, as well as themselves. This raises their quality of life and may be a strong incentive to have 0-1 children, thus lowering the population growth rate.

1 point earned for a rational drawback that follows up on the incentive given (acceptable incentive must be given to earn a point for drawback)

Examples of Drawbacks Accepted:

- Cultural/social issues in countries
- Interference with religious teaching
- Children punished for actions of parents
- Fewer workers to support an aging population/fill jobs/military strength
- Cost of programs to government and citizens
- Difficulty of dissemination of information/enforcement of regulations
- Rewards likely to attract people who already have all the children they want
- Reduced tax revenues
- Civil unrest
- Emigration/immigration with explanation on why a drawback
- Infringement of human rights
- May not work in rural or other areas because of need for child labor
- Increased government spending and debt leading to inflation
- Decreased quality of life for family without children
- Child dies (tied back to incentive)
- Increase in number of abandoned children/orphans
- Consequences/punishment for multiple births (e.g., twins)
- Increase in STDs, unwanted pregnancies, etc., that may accompany free birth control