FINAL Part II — Multiple Choice

There are 37 questions, each worth 1 mark (right answer) or 0 marks (wrong answers). We can only credit you with a mark for this exam component if your Scantron sheet is retrieved by an exam proctor.

Last Name (Print legibly) ______________________ **Student Number** ______________________

In the space below on this page, indicate any queries you have about this test; in particular, indicate any questions where you are convinced that either no, or more than one answer is correct.
Format for your queries: *Question #, affected answer(s) (#): comment*

Question 1:
Enter (A) to confirm that you have encoded your student number on the scantron sheet and printed your name on this booklet and the scantron sheet. Note that two fonts are used for the Greek letter phi: $\varphi = \Phi$.
We start Chapter 6 with two warm–up questions, followed by a Passage with 5 questions.

Question 2:
Ospreys are large North–American birds of prey that eat mainly fish. To catch prey they dive into the water and grab the fish with both feet, as seen in Fig. 1. In the picture, the bird has lifted the fish clear off the water, and accelerates itself with a powerful wing–stroke forward. In which direction does the bird exert a force on the fish?

Fig. 1

(A) Up
(B) Down
(C) Up and forward
(D) Down and backward
(E) None of the above

Question 3:
In 1968, Dick Fosbury introduced a new technique called the Fosbury flop at the Olympics in Mexico City. In this technique, athletes turn as they leap, flinging their body backward over the bar with the back arched. Throughout the jump the athlete's body is oriented perpendicular to the bar. An example is shown in Fig. 2. Neglecting air resistance, and assuming that the athlete clears the bar without touching it, which of the following statements about the athlete is correct at the instant the image is taken?

(A) Her body is in mechanical equilibrium
(B) Her body accelerates forward and upwards
(C) Her body only accelerates forward
(D) In the horizontal direction, her body is in mechanical equilibrium
(E) In the vertical direction, her body is in mechanical equilibrium

Fig. 2

Passage I (for Questions 4 to 8):
We study the Center playing on an American football team. Fig. 3 shows the Quarterback (background, No. 7) and the Center (foreground, No. 60). The picture is taken just before a play, when the Center, the Guards and the Tackles bend the upper body forward, forming about a $\theta = 45^0$ angle with the horizontal, then remain motionless until the play starts. Fig. 4 shows a sketch of the Center's trunk (system of interest) with the major forces identified that act on his trunk while in the posture of Fig. 3. These forces are: A force due to the weight of the head with helmet (labelled $\mathbf{W_H}$); a single force due to the weight of both arms (labelled $\mathbf{W_A}$); the weight of the trunk (labelled $\mathbf{W_T}$); the tension $\mathbf{T}$ in the back muscle; and the force $\mathbf{F_B}$ acting on the fifth lumbar vertebra. The figure indicates that the tension $\mathbf{T}$ forms a 11^0 angle with the spinal column.

Fig. 3

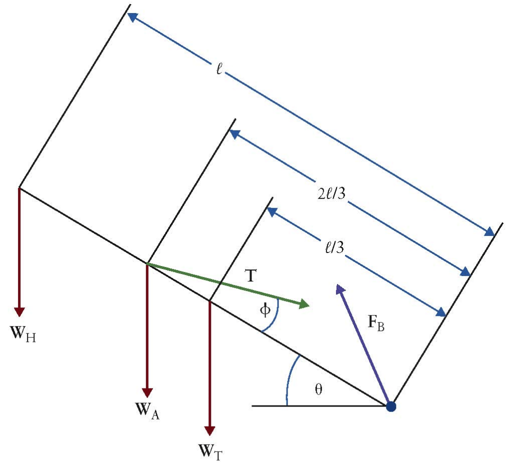

FIGURE 5.57

Fig. 4 (*Fig. 5.57 from the textbook*). *l* is the length of the system.

Question 4:
How many contact forces acting on the system of interest (the Center's trunk) are shown in Fig. 4?

(A) One or less
(B) Two
(C) Three
(D) Four
(E) Five or more

Question 5:
Is the system of interest in mechanical equilibrium?

(A) Yes
(B) Only in the horizontal direction
(C) Only in the vertical direction
(D) Only if the reaction forces to the forces shown in Fig. 4 are taken into account
(E) No, neither in the horizontal nor in the vertical direction

Question 6:
In the text, we referred to forces $\mathbf{W_H}$ and $\mathbf{W_A}$ as forces due to the weight of the head (and helmet) and the arms, respectively. Are these forces reaction forces to the respective weights?

(A) No
(B) Yes in the case of the head, due to the helmet
(C) Yes in the case of the arms, because there are two arms combined
(D) Both forces are reaction forces to the respective weights
(E) There isn't enough information given in Passage I and the two figures to determine an answer to Question 6.

Question 7:
Which of the following equations represents the x–component equation of Newton's first law as applied to the system of interest in Fig. 4? Note: the x–axis is chosen along the back, i.e. at an angle θ with the horizontal, pointing to the upper left. (Choose (E) if none of the four choices (A) – (D) is correct).

$$(A) \quad + T\sin\varphi - F_B\sin\theta = 0$$

$$(B) \quad + T\sin\varphi + F_B\sin\theta = 0$$

$$(C) \quad - T\sin\varphi - F_B\sin\theta = 0$$

$$(D) \quad - T\sin\varphi + F_B\sin\theta = 0$$

Question 8:
How many components does the y–component equation of Newton's first law as applied to the system of interest in Fig. 4 contain? Note: the y–axis is chosen perpendicular to the back, i.e., at an angle $\theta + 90^0$ with the horizontal, pointing to the upper right.

(A) One or less
(B) Two
(C) Three
(D) Four
(E) Five or more

Passage II (for Questions 9 to 11)

Fig. 5 shows an object of mass m_1 on an inclined surface. The angle of the inclined surface is $\theta = 30^0$ with the horizontal. The object m_1 is connected to a second object of different mass m_2 on a horizontal surface below an overhang that is formed by the inclined surface. Further, an external force $\mathbf{F_{ext}}$ is exerted on the object of mass m_1 along the incline, as shown. The magnitude of the external force is chosen such that both objects move with constant speed. We further assume that the surfaces and the pulley are frictionless, and the pulley and the connecting string are massless.

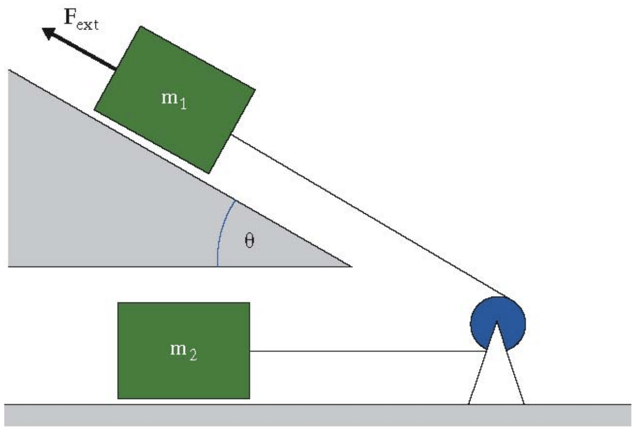

FIGURE 3.66

Fig. 5 (*Fig. 3.66 from the textbook*)

We assume that the initial state of the system is as shown, and the final state, a short while later, is reached when the lower object has moved 10 cm to the right. Neither object hits an obstacle, in particular, the object of mass m_2 is initially more than 10 cm to the left of the pulley.

Note: In the questions, we use index 1 for the object of mass m_1 and index 2 for the object of mass m_2.

Question 9:

How does the (gravitational) potential energy of the object of mass m_1 change from the initial to the final state?

(A) $\Delta E_{pot,\,1} > 0$ J

(B) $\Delta E_{pot,\,1} = 0$ J

(C) $\Delta E_{pot,\,1} = \Delta E_{pot,\,2}$

(D) $\Delta E_{pot,\,1} < 0$ J

(E) I can't tell from Fig. 5.

Question 10:

How does the kinetic energy of the object of mass m_2 change from the initial to the final state?

(A) $\Delta E_{kin,\,2} = \Delta E_{kin,\,1}$

(B) $\Delta E_{kin,\,2} > 0$ J

(C) $\Delta E_{kin,\,2} < 0$ J

(D) None of the choices (A) through (C) are correct.

(E) It could be any one of the three choices (A) through (C); which one I can't tell from Passage II and its figure.

Question 11:

How does the total energy of the system that consists of the two objects of masses m_1 and m_2 change from the initial to the final state?

(A) The total energy of a system is conserved, therefore the answer is $\Delta E_{total} = 0$ J

(B) $\Delta E_{total} > 0$ J

(C) $\Delta E_{total} < 0$ J

(D) None of the choices (A) through (C) are correct.

(E) It could be any one of the three choices (A) through (C); which one I can't tell from Passage II and its figure.

Question 12:

Consider the glass bowl with cherries shown in Fig. 6. Let's assume that the mass of the glass bowl and the mass of the cherries are the same, and everything is at room temperature. What can you conclude from Fig. 6 about the thermal energy of the system "cherries" compared to the system "glass bowl"?

Fig. 6

(A) $E_{thermal, glass bowl} = E_{thermal, cherries} > 0$
(B) $E_{thermal, glass bowl} = E_{thermal, cherries} = 0$
(C) $E_{thermal, glass bowl} > E_{thermal, cherries}$
(D) $E_{thermal, glass bowl} < E_{thermal, cherries}$
(E) none of the above

Question 13:

Fig. 7(i), at left, shows and object (black circle) on a frictionless inclined plane that forms an angle $\theta = 35^0$ with the horizontal. A person uses the force $\mathbf{F}_1$, which acts parallel to the incline, to pull the object with constant speed up by a distance *d*. Fig. 7(ii), at right, shows the same object on the same frictionless inclined plane, this time pulled by a person using force $\mathbf{F}_2$, which forms an angle of 35^0 with the surface of the incline. The person pulls the object again with constant speed up along the incline by the same distance *d*.

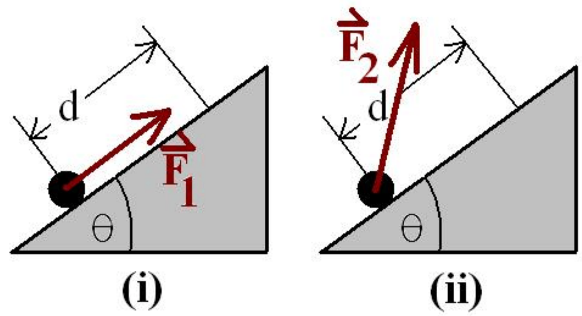

Fig. 7

In which case is more work done on the object?

(A) In case (i)
(B) In case (ii)
(C) The work is the same in both cases
(D) We cannot determine this, but only state that the work is positive in both cases.
(E) We cannot determine this, but only state that the work is negative in both cases.

Question 14:

We consider again Fig. 7. This time, the person in case (ii) choses $90^0 - \theta$ as the angle between the incline and the direction of the force $\mathbf{F}_2$. How does the answer to Question 13 change now?

(A) We obtain the same answer.
(B) The work in case (ii) is reduced.
(C) The work in case (ii) is increased.
(D) The experiment cannot be done this way.
(E) We need to know the mass of the object (black circle in Fig. 7) to answer this question.

Passage III (for Questions 15 to 18)

We consider a system that consists of one mol of an ideal gas. For this system, Fig 8 shows a cyclic process in a p–V diagram. The process consists of four steps, labelled I to IV, that connect four states of the system, labelled 1 to 4. The arrows indicate in which direction the process is operated.

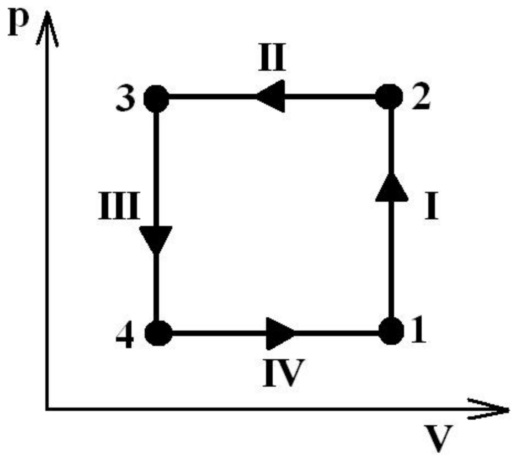

Fig. 8

Question 15:

If we draw a p–T diagram for the same process, which steps are still represented by a straight line?

(A) all four steps
(B) Steps I and III
(C) Steps II and IV
(D) Only one of the four steps
(E) None of the four steps

Question 16:

Which of the following does *not* apply to anyone of the four steps in Fig. 8?

(A) It is an isochoric process.
(B) It is an isothermal process.
(C) It is an isobaric process.
(D) Work is done on the ideal gas in the step.

Question 17:

Which labelled state of the system has the highest temperature?

(A) State 1
(B) State 2
(C) State 3
(D) State 4
(E) At least two states have the same temperature

Question 18:

How many of the steps in Fig. 8 can be done while the system is thermally isolated?

(A) None
(B) One step
(C) Two steps
(D) Three steps
(E) All fours steps

Question 19:

We study two ideal gases in separate containers. Both gases are initially at temperature T_0. Gas I differs from Gas II in that its molar mass is 4 times larger, $M_I = 4\ M_{II}$. By how much do I have to increase the temperature (ΔT) of Gas I so that both gases have the same root–mean–square speed?

(A) $\Delta T = T_0$
(B) $\Delta T = 2 \cdot T_0$
(C) $\Delta T = 3 \cdot T_0$
(D) $\Delta T = 4 \cdot T_0$
(E) $\Delta T = 5 \cdot T_0$

Question 20:

In which process does the work depend on the volume change ΔV in a linear fashion? Hint: This means that we can write $W = a + b \cdot \Delta V$, with $b \neq 0$.

(A) Isothermal process
(B) Isobaric process
(C) Isochoric process
(D) Adiabatic process
(E) A complete cycle of the Carnot process

Question 21:

Fig. 9 shows the p–V diagram for a standard man breathing regularly. The three curves show the alveolar pressure $p_{alveoli}$ (gauge pressure in the lungs), the pleural pressure p_{pleura} (gauge pressure in the pleural gap), and the transmural pressure difference between lungs and thorax $p_{alveoli} - p_{pleura}$ (gauge pressure difference of lungs and pleural gap). The latter two curves are modified between 3.0 L and 3.5 L (tidal volume): the pressure in the lungs is larger than atmospheric pressure during exhalation (upper dashed curve with arrow to the left) and it is smaller than atmospheric pressure during inhalation (lower dashed curve with arrow to the right). These pressure variations are needed to push or pull the air through the airways. The same changes occur for the pleural pressure (dash–dotted lines).

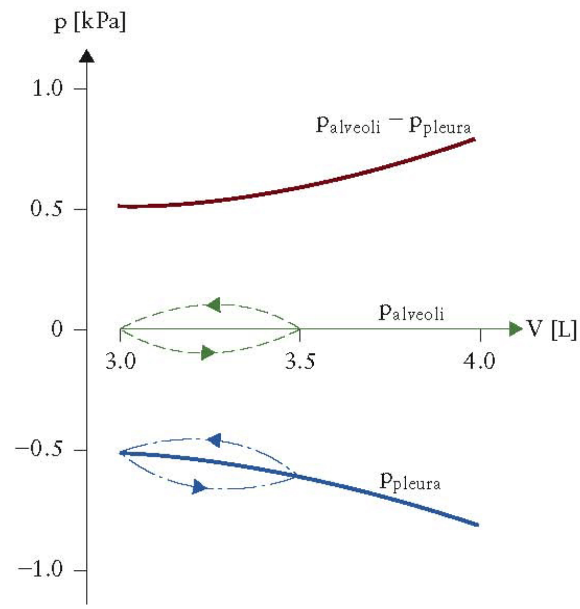

FIGURE 7.8

Fig. 9 (*Fig. 7.8 from the textbook*)

Based on the alveolar pressure, the work for the gas per cycle is:

(A) W = 0 J
(B) W > 0 J
(C) W < 0 J
(D) The work cannot be quantified from the figure

Passage IV (for Questions 22 and 23)

For poor heat conductors a new variable R, called the thermal resistance, is introduced. The thermal resistance of a piece of material of thermal conductivity λ and thickness *l* is defined as:

$$R = \frac{l}{\lambda}$$

With the thermal resistance we rewrite Fourier's law in the form:

$$\frac{Q}{t} = A\,\frac{T_{high} - T_{low}}{R}$$

in which A is the cross–sectional area of the piece of material.

The thermal resistance is also a convenient variable when studying thermal insulator materials stacked on top of each other. For example, when we consider the setup in Fig. 10, we find:

$$\frac{Q}{t} = A\,\frac{T_{high} - T_{low}}{R_1 + R_2}$$

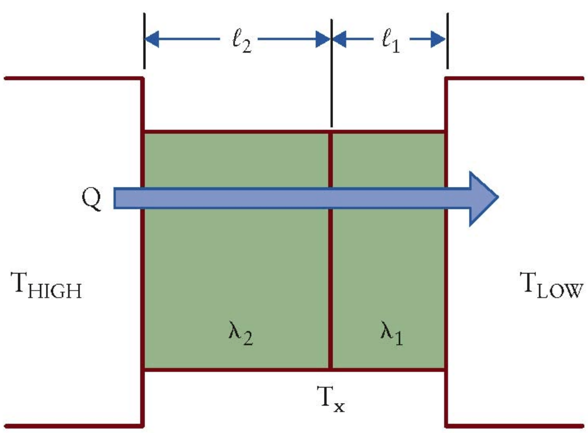

FIGURE 10.32

Fig. 10 (*Fig 10.32 in the textbook*)

Question 22:

Fig. 11 shows a two–layer system with a total of four square pieces. Each piece has an area A, thus the two systems each cover an area of 2A. The two arrangements in Fig. 11 differ in the order of the two materials (labelled 1 and 2). Which of the two arrangements in Fig. 11 provides for a better heat insulation? Note: assume that materials 1 and 2 are chosen such that $R_1 \gg R_2$.

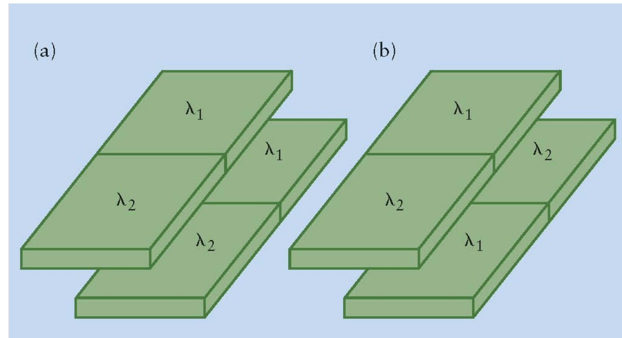

FIGURE 10.33

Fig. 11 (*Fig. 10.33 from the textbook*)

(A) The setup as shown in Fig. 11(a)
(B) The setup as shown in Fig. 11(b)
(C) Both arrangements are equally effective in preventing heat flow

Question 23:

If we assume in Fig. 10 that $\lambda_1 > \lambda_2$ and $l_1 + l_2 = L$ with L a fixed separation between the two heat reservoirs at temperatures T_{high} and T_{low}, for which of the following conditions is the heat flow indicated by the wide arrow in Fig. 10 a maximum?

(A) $l_1 = l_2$
(B) $R_1 = R_2$
(C) $R_1 = 0$
(D) $l_1 = L$
(E) $l_2 = L$

Question 24:

Arrhenius predicted the following temperature dependence of the diffusion coefficient:

$$D = D_0 \exp\left(-\frac{\Delta E}{kT}\right)$$

in which k is the Boltzmann constant and D_0 is the pre–exponential factor with unit *m²/s*. The notation exp(...) indicates the exponential function. Arrhenius then linearized this equation by taking the logarithm on both sides of the equation:

$$\ln(D) = \ln(D_0) - \frac{\Delta E}{kT}$$

Based on this second equation, on what does the logarithm of the diffusion coefficient depend linearly?

(A) the temperature
(B) the inverse thermal energy per particle
(C) the inverse activation energy
(D) the inverse root–mean–square of the diffusing atoms
(E) the pre–exponential factor D_0

Question 25:

During your research project you study diffusion in a given matrix. You establish a suitable diffusion length for the purpose of your work, based on tests with a diffusing species A. Your supervisor then requests that you change in the same matrix to diffusing species B, which has a diffusion coefficient that is four times that of species A. To obtain the same diffusion length, you will change the time of your experiment to:

(A) 1/16 of the time used for the experiment with species A
(B) 1/4 of the time used for the experiment with species A
(C) 1/2 of the time used for the experiment with species A
(D) 2 times the time used for the experiment with species A
(E) 4 times the time used for the experiment with species A

Passage V (for Questions 26 to 29)

You agree to fill in as a physics tutor for a sick friend. The problem you are supposed to solve on the blackboard goes as follows: A person who can see clearly when objects are between 30 cm and 1.5 m from the eye is to be fitted with bifocals. (a) The upper portion of the corrective lenses is designed such that the person can see distant objects clearly. What refractive power $\mathfrak{R}$ does that part of the lenses have? (b) The lower portion of the lenses has to enable the person to see objects comfortably at 25 cm. What refractive power $\mathfrak{R}$ does that part of the lenses have?

Your friend left with you a draft for the solutions that hasn't been proof–read:

Solution to part (a): To correct nearsightedness (myopia) we follow the arguments presented in the textbook: prescription lenses must convert an object at zero distance, $p = 0$, into a virtual image located at the farthest point the eye can see clearly. For the upper part of the prescription lenses this means $q = +\,1.5$ m, allowing us to calculate the focal length from the thin–lens formula:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = 0 + \frac{1}{+\,1.5\ \text{m}}$$

which yields $f = +\,1.5$ m. The positive value for the focal length f means that the lens must be converging. With this result we calculate the refractive power: $\mathfrak{R} = -\,0.67$ dpt.

Solution to part (b): The lower part of the lenses is supposed to correct for farsightedness. This case has been discussed in the textbook as hyperopia. Following the rationale presented there we require that objects at the desired near point of vision ($p = 25$ cm) have to form a virtual image at the actual near point of the person which is in the current case at image distance $q = -\,0.30$ cm. Note that this image is virtual as it must be formed on the same side of the lenses where the object is located to enable the eye to look at it. With these data we use the thin–lens formula again to determine the focal length of the prescription lenses:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{0.3\ \text{m}} + \frac{1}{-\,0.25\ \text{m}}$$

which yields $f = -\,0.67$ m. The negative value of the focal length means that the lenses are diverging. The refractive power is then $\mathfrak{R} = -\,1.5$ dpt.

Question 26:

We check through *Solution part (a)* first. Has your friend referred to the correct case?

(A) yes, this is a case of myopia (nearsightedness)
(B) no, this is a case of hyperopia (farsightedness)
(C) the whole problem has to be approached in a different fashion because the person cannot see clearly at the standard man's near point of $s_0 = 25$ cm
(D) no, the friend has mixed up cases (a) and (b)

Question 27:

We now check the numerical values used in *Solution part (a)*. With respect to the values for p (object distance) and q (image distance) you find in your friend's solution that

(A) Both p and q are stated correctly
(B) p is correct but q is wrong
(C) p is wrong while q is correct
(D) p and q are wrong

Question 28:

Since the tutorial session starts soon, you scribble any corrections on the printed solutions from your friend. How do you correct the final result for *Solution part (a)*?

(A) $\mathfrak{R} = -\,1.5$ dpt
(B) $\mathfrak{R} = -\,0.67$ dpt, i.e., your friend's solution had the right answer
(C) $\mathfrak{R} = 0.0$ dpt
(D) $\mathfrak{R} = +\,0.67$ dpt
(E) $\mathfrak{R} = +\,1.5$ dpt

Question 29:

We check through *Solution part (b)* next.
What is your conclusion:

(A) In part (b) the friend made no mistake
(B) There is a mistake in the equation written in a separate line, but the focal length and the refractive power are correct
(C) There is a mistake in the equation written in a separate line and all subsequent values are wrong
(D) The equation in a separate line is still correct, but the focal length and the refractive power are then calculated wrong
(E) Only the last calculation step, from the focal length to the refractive power is wrong

Question 30:
For a calculation you need the law of refraction, but you forgot to put it on your cheat sheet. From which of the following laws, which you happen to find on your cheat sheet, can you recover this law best?

(A) Law of reflection
(B) Thin lens formula
(C) Magnification formula for a spherical mirror
(D) Snell's law
(E) None of these, you are stuck for good

Question 31:
We used Fig. 12 in the lecture to discuss the focal point for a spherical mirror (shown at the bottom). The crossing of the reflected light rays at the focal point is illustrated with an experimental setup that produces parallel light rays to reach the mirror. In the current question, we now turn our attention to the lens shown near the top of the figure, just below a set of slits that select single rays that come from a point light source. Where is the focal point of that lens located?

(A) At the surface of the mirror
(B) At the point where all the light rays cross just above the mirror
(C) At the set of slits
(D) At the light source
(E) There is insufficient information provided to determine this location

Fig. 12

Question 32:
Fig. 13 shows a photo of a person looking at herself in a polished spoon. She uses the concave side of the spoon. You notice that the image is inverted. Where is the person relative to the spoon?

(A) On the side of the cameraman, and closer to the spoon than its focal length
(B) On the side of the cameraman, and farther to the spoon than its focal length
(C) Behind the spoon, and closer to the spoon than its focal length
(D) Behind the spoon, and farther to the spoon than its focal length
(E) The photo does not allow us to confirm one of the four choices (A) through (D)

Fig. 13

Passage VI (for Questions 33 to 34)

Next year you get involved in a biology research project for which the researchers use an electron microscope. Since we haven't covered that instrument in the course, you grab the textbook and read the one page description to get a first idea. In that section included is Fig. 14, which shows a sketch of the electron microscope at the left and the light microscope at the right. Looking at the familiar optical compound microscope at the right, you recognize the location of the object (position 3) and a light source for illumination at the top.

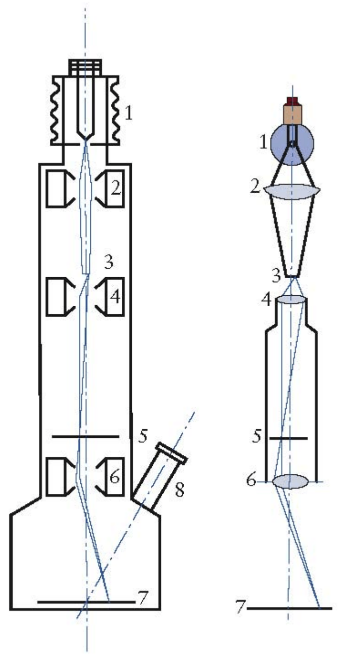

FIGURE 19.8

Fig. 14 (*Fig. 19.8(a) in the textbook*)

Question 33:

Since we discussed the light microscope, you recognize its other key components without having to read the complete figure caption. Which is correct?

(A) 2 is the objective lens and 4 is the eye piece
(B) 2 is the eye piece and 6 is the objective lens
(C) 2 is the objective lens and 6 is the eyepiece
(D) 4 is the eye piece and 6 is the objective lens
(E) 4 is the objective lens and 6 is the eyepiece

Question 34:

Number 5 in the right part of Fig. 14 is

(A) The location of the specimen
(B) The location of the observer
(C) The location where a film has to be placed to photograph the magnified image
(D) The location of the image of the objective lens
(E) The location of the image of the eyepiece

Question 35:

The angular magnification of the compound microscope depends on the following term that does not contribute to the angular magnification of a magnifying glass:

(A) The near point of the standard man
(B) The focal length of the eyepiece
(C) The magnification of the objective lens
(D) The distance of the observer to the eyepiece

Question 36:

For magnifying glass I you calculate an angular magnification of m = 5. If you want to achieve the same angular magnification with magnifying glass II that has twice the focal length than magnifying glass I, what near point $s_{0,\,II}$ do you need to use with magnifying glass II? ($s_{0,\,I}$ is the near point used for magnifying glass I).

(A) $s_{0,\,II} = 2 \cdot s_{0,\,I}$
(B) $s_{0,\,II} = 4 \cdot s_{0,\,I}$
(C) $s_{0,\,II} = \frac{1}{2}\, s_{0,\,I}$
(D) $s_{0,\,II} = \frac{1}{4}\, s_{0,\,I}$
(E) The same angular magnification cannot be obtained

Question 37:

Using a concave mirror, you want an image of the same size of the object, but inverted. Where do you place the object?

(A) As close as you want to the mirror
(B) At the focal point
(C) Just beyond the focal point
(D) At the centre of curvature of the mirror
(E) Just beyond the centre of curvature of the mirror