Review Questions

13.1 Define direct time study.

13.2 Identify the five steps in the direct time study procedure.

13.3 Why is it so important to define and document the standard method as precisely and thoroughly as possible?

13.4 What is the snapback timing method when using a stopwatch during direct time study?

13.5 What is the continuous timing method when using a stopwatch during direct time study?

13.6 Why is performance rating a necessary step in direct time study?

13.7 Why is an allowance added to the normal time to compute the standard time?

13.8 What are some of the causes of variability in the observed work element times that occur from cycle to cycle?

13.9 Why is the student t distribution rather than the normal distribution used in the calculation of the number of work cycles to be timed?

13.10 What is the difference between elemental performance rating and overall performance rating?

13.11 What are the characteristics of a well-implemented performance rating system?

13.12 What are the advantages of electronic stopwatches compared to mechanical stopwatches?

Problems

Note: Some of the problems in this set require the use of parameters and equations that are defined in Chapter 2.

Determining Standard Times for Pure Manual Tasks

13.1 The observed average time in a direct time study was 2.40 min for a repetitive work cycle. The worker's performance was rated at 110% on all cycles. The personal time, fatigue, and delay allowance for this work is 12%. Determine (a) the normal time and (b) the standard time for the cycle.

13.2 The observed element times and performance ratings collected in a direct time study are indicated in the table below. The snapback timing method was used. The personal time, fatigue, and delay allowance in the plant is 14%. All elements are regular elements in the work cycle. Determine (a) the normal time and (b) the standard time for the cycle.

Work element	a	b	c	d
Observed time (min)	0.22	0.41	0.30	0.37
Performance rating	90%	120 %	100 %	90%

13.3 The standard time is to be established for a manual work cycle by direct time study. The observed time for the cycle averaged 4.80 min. The worker's performance was rated at 90% on all cycles observed. After eight cycles, the worker must exchange parts containers, which took 1.60 min, rated at 120%. The PFD allowance for this class of work is 15%. Determine (a) the normal time and (b) the standard time for the cycle. (c) If the worker produces 123 work units during an 8-hour shift, what is the worker's efficiency?

13.4 The snapback timing method was used to obtain the average times and performance ratings for work elements in a manual repetitive task. See table below. All elements are worker-controlled. All elements were performance rated at 80%. Element e is an irregular element performed every five cycles. A 15% allowance for personal time, fatigue, and delays is applied to the cycle. Determine (a) the normal time and (b) the standard time for this cycle. If the worker's performance during actual production is 120% on all manual elements for seven actual hours worked on an eight-hour shift, (c) how many units will be produced and (d) what is the worker's efficiency?

Work element	a	b	c	d	e
Observed time (min)	0.32	0.85	0.48	0.55	1.50

13.5 The continuous timing method is used to direct time study a manual task cycle consisting of four elements: a, b, c, and d. Two parts are produced each cycle. Element d is an irregular element performed once every six cycles. All elements were performance rated at 90%. The PFD allowance is 11%. Determine (a) the normalized time for the cycle and (b) the standard time per part. (c) If the worker completes 844 parts in an 8-hour shift during which she works 7 hours and 10 min, what is the worker's efficiency?

Element	a	b	c	d
Observed time (min)	0.35	0.60	0.86	1.46

13.6 The readings in the table below were taken by the snapback timing method of direct time study to produce a certain subassembly. The task was performance rated at 85%. In addition to the above regular elements, an irregular element must be included in the standard: each rack holds 20 mechanism plates and has universal wheels for easy movement. After completing 20 subassemblies, the operator must move the rack (which now holds the subassemblies) to the aisle and then move a new empty rack into position at the workstation. This irregular element was timed at 2.90 min and the operator was performance rated at 80%. The PFD allowance is 15%. Determine (a) the normalized time for the cycle, (b) the standard time, and (c) the number of parts produced by the operator, if he/she works at standard performance for a total of 6 hours and 57 min during the shift.

Element and description	Observed time (min)
1. Pick up mechanism plate from rack and place in fixture.	0.42
2. Assemble motor and fasteners to front side of plate.	0.28
3. Move to other side of plate.	0.11
4. Assemble two brackets to plate.	0.56
5. Assemble hub mechanism to brackets.	0.33
6. Remove plate from fixture and place in rack.	0.40

13.7 The time and performance rating values in the table below were obtained using the snapback timing method on the work elements in a certain manual repetitive task. All elements are worker-controlled. All elements were performance rated at 85%. Element e is an irregular element performed every five cycles. A 15% PFD allowance is applied to the cycle. Determine (a) the normal time and (b) the standard time for this cycle. If the worker's performance during actual production is 125% on all manual elements for seven actual hours worked on an eight-hour shift, (c) how many units will be produced and (d) what is the worker's efficiency?

Work element	a	b	c	d	e
Observed time (min)	0.61	0.42	0.76	0.55	1.10

Determining Standard Times for Worker-Machine Tasks

13.8 The snapback timing method was used to obtain average times for work elements in one work cycle. The times are given in the table below. Element d is a machine-controlled element and the time is constant. Elements a, b, c, e, and f are operator-controlled and were performance rated at 80%; however, elements e and f are performed during the machine-controlled element d. The machine allowance is zero (no extra time is added to the machine cycle), and the PFD allowance is 14%. Determine (a) the normal time for the cycle and (b) the standard time for the cycle.

Element	a	b	c	d	e	f
Observed time (min)	0.24	0.30	0.17	0.76	0.26	0.14

13.9 The continuous timing method in direct time study was used to obtain the element times for a worker-machine task as indicated in the table below. Element c is a machine-controlled element and the time is constant. Elements a, b, d, e, and f are operator-controlled and external to the machine cycle, and were performance rated at 80%. If the machine allowance is 25%, and the worker allowance for personal time, fatigue, and delays is 15%, determine (a) the normal time and (b) standard time for the cycle. (c) If the worker completed 360 work units working 7.2 hours on an 8-hour shift, what was the worker's efficiency?

Element	a	b	c	d	e	f
Observed time (min)	0.18	0.30	0.88	1.12	1.55	1.80

13.10 A worker-machine cycle is direct time studied using the continuous timing method. One part is produced each cycle. The cycle consists of five elements: a, b, c, d, and e. Elements a, c, d, and e are manual elements, external to machine element b. Every 16 cycles the worker must replace the parts container, which was observed to take 2.0 min during the time study. All worker elements were performance rated at 80%. The PFD allowance is 16%, and the machine allowance = 20%. Determine (a) the normalized time for the cycle, (b) the standard time per part. (c) If the worker completes 220 parts in an 8-hour during which he works 7 hours and 12 min, what is the worker's efficiency?

Element	Description	Cumulative observed time (min)
a	Worker loads machine and starts automatic cycle.	0.25
b	Machine automatic cycle	1.50
c	Worker unloads machine.	1.75
d	Worker files part to size.	2.30
e	Worker deposits part in container.	2.40

13.11 In the preceding problem, a recommendation has been submitted for elements d and e to be performed as internal elements (accomplished simultaneously) with machine element b. The worker would file the part from the previous cycle and deposit it in the container while the current part is being processed in the machine automatic cycle. Performance rating and allowances are the same as in the previous problem. Determine (a) the normal time for the cycle, (b) the standard time per part. (c) If the worker's efficiency is 115% and he works a total of 7 hours and 12 min during an 8-hour shift, how many parts will be produced?

13.12 The snapback method was used to time study a worker-machine cycle consisting of three elements: a, b, and c. Elements a and b are worker-controlled and were performance rated at 100% during the time study. Element c is machine-controlled. Elements b and c are performed simultaneously. The PFD allowance = 12% and the machine allowance = 10%. One work piece is produced each cycle. Determine (a) the normal time and (b) standard time for the cycle. (c) If the worker works 7 hours and 10 min during an 8-hour shift, and his performance level is 135%, how many pieces are completed?

Element	a	b	c
Observed time (min)	1.25	0.90	0.80

13.13 The snapback timing method in direct time study was used to obtain the times for a worker-machine task. The recorded times are listed in the table below. Element c is a machine-controlled element and the time is constant. Elements a, b, and d are operator-controlled and were performance rated at 90%. Elements a and b are external to machine-controlled element c. Element d is internal to the machine element. The machine allowance is zero, and the PFD allowance is 13%. Determine (a) the normal time and (b) the standard time for the cycle. The worker's actual time spent working during an 8-hour shift was 7.08 hours, and he produced 420 units of output during this time. Determine (c) the worker's performance during the operator-controlled portions of the cycle and (d) the worker's efficiency during this shift.

Element	a	b	c	d
Observed time (min)	0.34	0.25	0.68	0.45

13.14 The following table lists the average work element times obtained in a direct time study using the snapback timing method. Elements a and b are operator-controlled. Element c is a machine-controlled element and its time is constant. Element d is a worker-controlled irregular element performed every five cycles. Elements a, b and d were performance rated at 80%. The worker is idle during element c, and the machine is idle during elements a, b, and d. One product unit is produced each cycle. To compute the standard, no machine allowance is applied to element c, and a 15% PFD allowance is applied to elements a, b, and d. (a) Determine the standard time for this cycle. (b) If the worker produces 220 units on an 8-hour shift during which 7.5 hours were actually worked, what was the worker's efficiency. (c) For the 220 units in (b), what was the worker's performance during the operator-paced portion of the cycle?

Element	a	b	c	d
Observed time (min)	0.60	0.45	1.50	0.75

13.15 The continuous timing method in direct time study was used to obtain the times for a worker-machine task as indicated in the table below. Element c is a machine-controlled element and the time is constant. Elements a, b, d, e, and f are operator-controlled and were performance rated at 95%; they are all external elements performed in sequence with machine element c. The machine allowance is 30%, and the PFD allowance is 15%. Determine (a) the normal time and (b) standard time for the cycle. (c) If the operator works at 100% of standard performance in production and one part is produced each cycle, how many parts are produced if the total time worked during an 8-hour day is 7.25 hours? (d) For the number of parts computed in (c), what is the worker's efficiency for this shift?

Element	a	b	c	d	e	f
Observed time (min)	0.22	0.40	1.08	1.29	1.75	2.10

13.16 The snapback timing method was used to obtain average time and performance rating values for the work elements in a certain repetitive task. The values are given in the table below. Elements a, b, and c are worker-controlled. Element d is a machine-controlled element and its time is the same each cycle (N.A. means performance rating is not applicable). Element c is performed while the machine is performing its cycle (element d). Element e is a worker-controlled irregular element performed every six cycles. The machine is idle during elements a, b, and e. Four product units are produced each cycle. The machine allowance is zero, and a 15% PFD allowance is applied to the manual portion of the cycle. Determine (a) the normal time and (b) the standard time for this cycle. If the worker's performance during actual production is 140% on all manual elements for seven actual hours worked on an eight-hour shift, (c) how many units will be produced and (d) what is the worker's efficiency?

Work element	a	b	c	d	e
Observed time (min)	0.65	0.50	0.50	0.55	1.14
Performance rating	90%	100 %	120 %	N.A.	80%

13.17 The continuous timing method was used to obtain the times for a worker-machine task. Only one cycle was timed. The observed time data are recorded in the table below. Elements a, b, c, and e are worker-controlled elements. Element d is machine controlled. Elements a, b, and e are external to the machine-controlled element, while element c is internal. There are no irregular elements. All worker-controlled elements were performance rated at 80%. The PFD allowance is 15% and the machine allowance is 20%. Determine (a) the normal time and (b) standard time for the cycle. (c) If worker efficiency = 100%, how many units will be produced in one 9-hour shift? (d) If the actual time worked during the shift was 7.56 hours, and the worker performance = 120%, how many units would be produced?

Worker element (min)	a (0.65)	b (1.80)	c (4.25)	e (5.45)
Machine element (min)			d (4.00)	

13.18 The continuous stopwatch timing method was used to obtain the observed times for a worker-machine task. Only one cycle was timed. The data are recorded in the table below. The times listed indicate the stopwatch reading at the end of the element. Elements a, b, and d are worker-controlled elements. Element c is machine controlled. Elements a and d are external to the machine-controlled element, while element b is internal. Every four cycles, there is an irregular worker element that takes 1.32 min rated at 100% performance. For determining the standard time, the PFD allowance is 15% and the machine allowance is 30%. Determine (a) the normal time and (b) standard time for the cycle. (c) If worker efficiency = 100%, how many units will be produced in one 8-hour shift? (d) If the actual time worked during the shift was 6.86 hours, and the worker performance = 125%, how many units would be produced?

Worker element	Description of worker element	Time (min)	Perform. rating	Machine element	Description of machine element	Time (min)
a	Acquire workpart from tray, cut to size, and load into machine	1.24	100%	(idle)		
b	Enter machine settings for next cycle	4.24	120%	c	Automatic cycle controlled by machine settings entered in previous cycle	4.54
d	Unload machine and place part on conveyor	5.09	80%	(idle)		

13.19 The snapback timing method in direct time study was used to obtain the times for a worker-machine task. The recorded times are listed in the table below. Element d is a machine-controlled element and the time is constant. Elements a, b, c, e, and f are operator-controlled and were performance rated at 90%. Element f is an irregular element, performed every five cycles. The operator-controlled elements are all external to machine -controlled element d. The machine allowance is zero, and the PFD allowance is 13%. Determine (a) the normalized time for the cycle and (b) the standard time for the cycle. The worker's actual time spent working during an 8-hour shift was 7.08 hours, and he produced 400 units of output during this time. Determine (c) the worker's performance during the operator-controlled portions of the cycle and (d) the worker's efficiency during this shift.

Element	a	b	c	d	e	f
Observed time (min)	0.14	0.25	0.18	0.45	0.20	0.62

13.20 For a worker-machine task, the continuous timing method was used to obtain the times indicated in the table below. Element c is a machine-controlled element and the time is constant. Elements a, b, d, and e are operator-controlled and were performance rated at 100%; however, element d is performed simultaneously with element c. The machine allowance is 16%, and the PFD allowance is 16%. Determine (a) the normal time and (b) standard time for the cycle. (c) If the operator works at 140% of standard performance in production and two parts are produced each cycle, how many parts are produced if the total time worked during an 8-hour day is 7.4 hours? (d) For the number of parts computed in (c), what is the worker's efficiency for this shift?

Element	a	b	c	d	e
Observed time (min)	0.30	0.65	1.65	1.90	2.50

13.21 For a certain repetitive task, the snapback timing method was used to obtain the average work element times and performance ratings listed in the table below. Elements a, b, and c are worker-controlled. Element d is a machine-controlled element and its time is the same each cycle (N.A. means performance rating is not applicable). Element c is performed while the machine is performing its cycle (element d). Element e is a worker-controlled irregular element performed every five cycles. The machine is idle during elements a, b, and e. One part is produced each cycle. The machine allowance is 15%, and a 15% PFD allowance is applied to the manual portion of the cycle. Determine (a) the normal time and (b) the standard time for this cycle. If the worker's performance during actual production is 130% on all manual elements for 7.3 actual hours worked on an eight hour shift, (c) how many units will be produced and (d) what is the worker's efficiency?

Work element	a	b	c	d	e
Observed time (min)	0.47	0.58	0.70	0.75	2.10
Performance rating	90%	80%	110 %	N.A.	85%

13.22 The work element times for a repetitive work cycle are listed in the table below, as determined in a direct time study using the snapback timing method. Elements a and b are operator-controlled. Element c is a machine-controlled element and its time is constant. Element d is a worker-controlled irregular element performed every ten cycles. Elements a and b were performance rated at 90%, and element d was performance rated at 75%. The worker is idle during element c, and the machine is idle during elements a, b, and d. One product unit is produced each cycle. No special allowance is added to the machine cycle time (element c), but a 15% allowance factor is applied to the total cycle time. (a) Determine the standard time for this cycle. If the worker produced 190 units on an 8-hour shift during which 7 hours are actually worked, (b) what was the worker's efficiency, and (c) what was his performance during the operator-paced portion of the cycle?

Work element	a	b	c	d
Observed time (min)	0.75	0.30	1.62	1.05

Number of Cycles

13.23 Seven cycles have been observed during a direct time study. The mean for the largest element time = 0.85 min, and the corresponding sample standard deviation s = 0.15 min, which was also the largest. If the analyst wants to be 95% confident that the mean of the sample was within ±10% of the true mean, how many more observations should be taken?

13.24 A total of 9 cycles have been observed during a time study. The mean for the largest element time = 0.80 min, and the corresponding sample standard deviation s = 0.15 min, which was also the largest. If the analyst wants to be 95% confident that the mean of the sample was within ±0.10 min of the true mean, how many more observations should be taken?

13.25 A total of 6 cycles have been observed in a direct time study. The mean for the largest element time = 0.82 min, and the corresponding sample standard deviation s = 0.11 min, which was also the largest. If the analyst wants to be 95% confident that the mean of the sample was within ±0.10 min of the true mean, how many more observations should be taken?

13.26 Ten cycles have been observed during a direct time study. The mean time for the longest element was 0.65 min, and the standard deviation calculated on the same data was 0.10 min. If the analyst wants to be 95% confident that the mean of the sample was within ±8% of the true mean, how many more observations should be taken?

13.27 Six cycles have been observed during direct time study. The mean time for the longest element was 0.82 min, and the standard deviation calculated on the same data was 0.13 min. If the analyst wants to be 90% confident that the mean of the sample was within ±0.06 min of the true mean, how many more observations should be taken?

13.28 Six cycles have been observed during a direct time study. The mean for the largest element time = 1.00 min, and the corresponding sample standard deviation s = 0.10 min. (a) Based on these data, what is the 90% confidence interval on the 1.0 min element time? (b) If the analyst wants to be 90% confident that the mean of the sample was within ±10% of the true mean, how many more observations should be taken?

13.29 A total of 9 cycles have been observed during a direct time study. The mean for the largest element time = 1.30 min, and the corresponding sample standard deviation s = 0.20 min. (a) Based on these data, what is the 95% confidence interval on the 1.30 min element time? (b) If the analyst wants to be 98% confident that the mean of the sample was within ±5% of the true mean, how many more observations should be taken?

Performance Rating

13.30 One of the traditional definitions of standard performance is a person walking at 3.0 miles per hour. Given this, what is the performance rating of a long-distance runner who breaks the four-minute mile?

13.31 In 1982, the winner of the Boston Marathon was A. Salazar, whose time was 2 hours, 23 min and 3.2 sec. The marathon race covers 26 miles and 385 yards. Given that one of the traditional definitions of standard performance is a person walking at 3.0 miles per hour, what was Salazar's performance rating in the race.