MIDTERM 2 SOLUTION   Date: April 26, 2007

General Instructions
All work is to be completed in a bluebook – answers not recorded in a bluebook will not be graded.   Place the exam sheets on the inside of your bluebook when finished and hand them in back with the bluebook.

If you have a question during any portion of this exam, raise your hand and speak to the proctor. Write legibly.

Question 1 [20 points]
1.a. What characteristics make a bidder responsive? Responsible? [4 points]
Responsive bidder (in B 158):
  a. [1 point] Has filed out and signed the bid forms in accordance with the bidding instructions.
  b. [1 point] Has submitted a qualified bid in full conformance with the requirements of the bid documents.
Responsible bidder (in B 159):
  a. [1 point] Possesses sufficient financial resources to undertake the project
  b. [1 point] Has the necessary experience and a track of record indicating the ability to execute successfully the work of the contract.

1.b. Discuss at least three purposes of unbalanced bidding. [6 points]
In R 141:
  a. [2 points] To receive more money at the early stages of construction that will help finance the remainder of the project.
  b. [2 points] To increase profit without increasing the bid price, where there is reason to believe that the bid quantities and the final quantities will vary.
  c. [2 points] To reduce the bid price without reducing profit under some circumstances as in (b).

1.c. Under the generalized rules of contract interpretation, what is the priority of the following factors: [6 points]
        a. Course of dealing
        b. Customs and trade practices
        c. Express terms
        d. Course of performance
The priority as follows (in B 299):
  a. [2 points] Express contract terms are more important than course of performance, course of dealing, or the customs and trade practices of the industry.
  b. [2 points] Course of performance is more important than course of dealing or the customs and trade practices if the industry.

c. [2 points] Course of dealing will take precedence over the customs and trade practices of the industry.

Note: If students who correctly rank these factors as (a) express terms; (b) course of performance; (c) course of dealing; and (d) customs and trade practices will get 4 of 6 points.

1.d. Discuss at least three ways learning curves can be used by contractors. [4 points]
   a. [1.5 points] For better planning and scheduling
   b. [1.5 points] For proper resource leveling
   c. [1 point] For measuring Impacts of Changes (Disruptions) to (1) re-plan the work when there is disruption and (2) to measure the loss of productivity (impact of changes) and get compensation for that from owner.

Note: Students will get 1.5 of 4, 3 of 4, and 4 of 4 points if correctly list only one way, two ways, and all three ways, respectively.

Question 2 [10 points]
2.a. What is A+B bidding? Discuss at least one benefit of A+B bidding. [5 points]
From lecture on 3/06/2007:
[3 points] A + B bidding is a cost-plus-schedule bidding procedure that selects the lowest bidder based on a monetary combination of the contract bid items (A) and the schedule (B) needed to finish the project.

[2 points] One benefit of A+B bidding is time savings. A+B bidding is used to encourage the contractor to reduce the overall project schedule.

2.b. Apply A+B bidding to a road construction project in Table 2.1 below, which contractor would be awarded? The public owner estimates that the average total cost of road users will be $25,000 per day if this road is under construction [4 points]

Table 2.1. Bidding information of the road project

Contractor	Bid Amount	Project Duration (Day)
A	$7,300,000	150
B	$8,900,000	120
C	$7,550,000	135
D	$8,750,000	110

[2 points] Combined cost of each bidder:
Bidder A: $7,300K + $25Kx150 = $11,050K
Bidder B: $8,900K + $25Kx120 = $11,900K
Bidder C: $7,550K + $25Kx135 = $10,925K → Lowest combined cost
Bidder D: $8,750K + $25Kx110 = $11,500K

[2 points] Bidder C would be awarded because she offers the lowest combined cost.

2.c. If the above contractor completes the project as planned, how much would she receive from the owner of this project? [1 point]
[1 point] Contractor C would receive $7,550,000 if she completes the project as planned.

Question 3 [10 points]
Consider the following case: (B 79)

Base rate	$36.50 per hour
Health and welfare	$9.50 per hour
Pension	$1.25 per hour
Vacation	$0.75 per hour

A project required 125,500 actual masonry work-hours, of which 18% were performed on an overtime basis. Overtime work was paid at time-and-a-half. How much labor expense would the contractor employer incur if the union agreement called for payment of union fringes on:
3.a. an hours-worked basis [5 points]
3.b. an hours-paid basis [5 points]

Similar to B 79:

For both (3.a) and (3.b):
Hours-worked = 125,500 hours
[1 point] Standard-time work hours = 125,500x(1 – 0.18) = 102,910 work-hours
[1 point] Overtime work hours = 125,500x0.18 = 22,590 work-hours
[1 point] Hours-paid = 102,910 + 1.5x22,590 = 136,795 hours

[1 point] Worker gets = $36.50x136,795 = $4,993,017.5

Trust funds get:
3.a. [2 points] Trust funds get based on an hours-worked basis = ($9.50 + $1.25 + $0.75)x125,500 = $1,443,250.
[1 point] Labor expense = $4,993,017.5 + $1,443,250 = $6,436,267.5
3.b. [2 points] Trust funds get based on an hours-paid basis = ($9.50 + $1.25 + $0.75)x136,795 = $1,573,142.5
[1 point] Labor expense = $4,993,017.5 + $1,573,142.5 = $6,566,160.

Question 4 [15 points]
Your company needs to prepare bid price for a mass foundation concreting project in 2007. The volume of ready mixed concrete (2000 psi) to be placed is 910 cubic yard. You plan to use a crane and bucket. R.S. Means indicates that the cost for the ready mixed concrete material is $69.50 per cubic yard and the cost for concrete placement is $23.10 per cubic yard, all costs in year 2004 dollar. The daily output of the concrete placement is 130 cubic yard. Material costs have escalated at 5% per year. The increase in the cost of concrete placement has been negligible for the last few years. The supply of ready mixed concrete is unlimited. The project field overhead is $1000 per working day. Home office overhead is 10% of project direct cost.
4.a. What is the estimated direct cost of this project? [5 points]
[2 points] Material costs in year 2007 = $69.50x(1 + 0.05)^3 = $80.45/c.y.
[1 point] Placement costs in year 2007 = $23.10/c.y.
[2 points] Estimated direct costs = 910x($80.45 + $23.10) = $94,230.5

4.b. What is the indirect cost of this project? [5 points]
[1 point] The number of project working days = quantity/daily output = 910/130 = 7 days.
[1 point] Project field overhead = $1000x7 = $7000
[1 point] Home office overhead = $94,230.5x0.1 = $9,423.05
[2 points] Indirect costs = project field overhead + home office overhead = $16,423.05
4.c. What is your bid price if your company applies a 15% profit margin on project's direct costs? [5 points]
[2 points] Profit margin = $94,230.5x0.15 = $14,134.575
[3 points] Bid price = Direct costs + Indirect costs + Profit margin = $94,230.5 + $16,423.05 + $14,134.575 = $124,788.

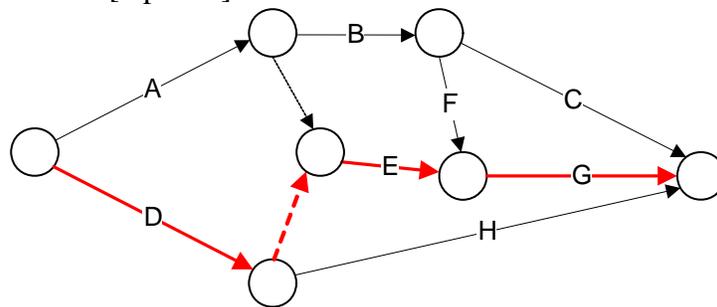## Question 5 [23 points]
Table 5.1 defines the activities of a small project

Activity	Duration (day)	Predecessor
A	3	-
B	1	A
C	2	B
D	7	-
E	8	D, A
F	3	B
G	1	E, F
H	2	D

5.a. Draw a activity-on-arrow (AOA) network with minimum dummy activities. Identify all possible paths from this network [6 points]
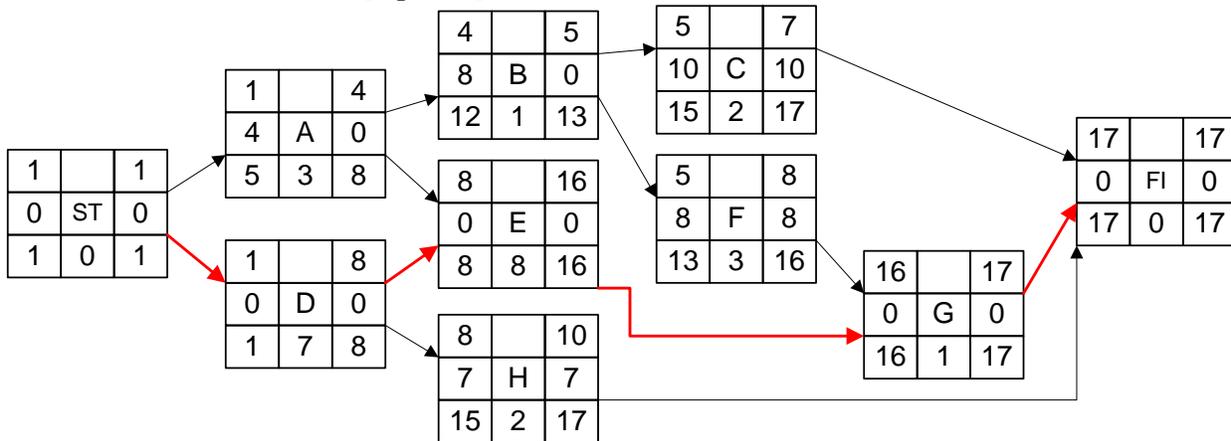
The AOA network is below [5 points]:

Note: An incorrect network will gain no point. Each additional and/or unnecessary dummy activities will be deducted 1 points but total deductions should not be greater than 5 points.

Five paths are below [1 point]:

Path	Sum of Durations	Duration
A – B – C	3 + 1 + 2	6
A – B – F – G	3 + 1 + 3 + 1	8
A – E – G	3 + 8 + 1	12
D – H	7 + 2	9
D – E – G	7 + 8 + 1	16

4

5.b. Draw a activity-on-node (AON) network. Calculate ES, EF, LS, LF, TF, and FF of each activities and the project duration. Identify the critical path(s) and critical activities. [7 points]

The AON network is below [6 points]:

Node ST: | 1 | | 1 | / | 0 | ST | 0 | / | 1 | 0 | 1 |
Node A: | 1 | | 4 | / | 4 | A | 0 | / | 5 | 3 | 8 |
Node B: | 4 | | 5 | / | 8 | B | 0 | / | 12 | 1 | 13 |
Node C: | 5 | | 7 | / | 10 | C | 10 | / | 15 | 2 | 17 |
Node D: | 1 | | 8 | / | 0 | D | 0 | / | 1 | 7 | 8 |
Node E: | 8 | | 16 | / | 0 | E | 0 | / | 8 | 8 | 16 |
Node F: | 5 | | 8 | / | 8 | F | 8 | / | 13 | 3 | 16 |
Node H: | 8 | | 10 | / | 7 | H | 7 | / | 15 | 2 | 17 |
Node G: | 16 | | 17 | / | 0 | G | 0 | / | 16 | 1 | 17 |
Node FI: | 17 | | 17 | / | 0 | FI | 0 | / | 17 | 0 | 17 |

Note: Each wrong relationship or number will be deducted 1 point but total deductions should not greater than 6 points.
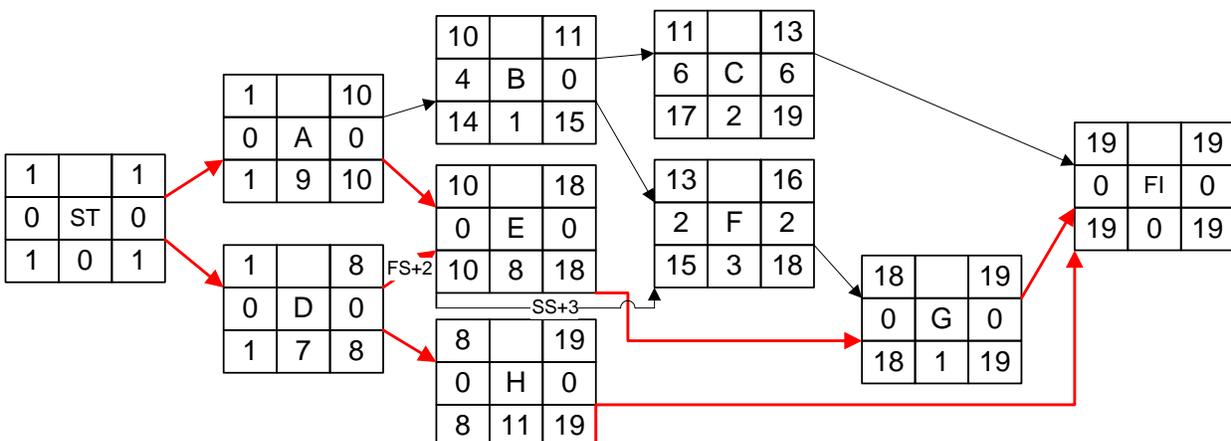
[0.5 point] One critical path: Start – D – E – G – Finish (D – E – G is also complete)
[0.5 point] Critical activities: D, E, and G

5.c. Redo question (5.b) given the following additional information: [7 points]
      a. A is delayed six days.
      b. D finishes after two days before E can start.
      c. H is delayed nine days.
      d. F can start three days after E starts.

The new AON network is below [6 points]:

Node ST: | 1 | | 1 | / | 0 | ST | 0 | / | 1 | 0 | 1 |
Node A: | 1 | | 10 | / | 0 | A | 0 | / | 1 | 9 | 10 |
Node B: | 10 | | 11 | / | 4 | B | 0 | / | 14 | 1 | 15 |
Node C: | 11 | | 13 | / | 6 | C | 6 | / | 17 | 2 | 19 |
Node D: | 1 | | 8 | / | 0 | D | 0 | / | 1 | 7 | 8 | (FS+2)
Node E: | 10 | | 18 | / | 0 | E | 0 | / | 10 | 8 | 18 |
Node F: | 13 | | 16 | / | 2 | F | 2 | / | 15 | 3 | 18 | (SS+3)
Node H: | 8 | | 19 | / | 0 | H | 0 | / | 8 | 11 | 19 |
Node G: | 18 | | 19 | / | 0 | G | 0 | / | 18 | 1 | 19 |
Node FI: | 19 | | 19 | / | 0 | FI | 0 | / | 19 | 0 | 19 |

Note: Each wrong relationship or number will be deducted 1 point but total deductions should not greater than 6 points.

[0.75 point] Three critical paths:
Start – A – E – G – Finish
Start – D – E – G – Finish
Start – D – H – Finish
[0.25 point] Five critical activities: A, D, E, G, and H

5.d. Discuss changes between the network in (5.c) and the one in (5.b) [3 points]
The project duration is increased from 16 days to 18 days. Compared to the old network the new one is more critical paths and critical activities. The number of critical activities is greater than that of non-critical activities in the new network. Thus, there must be more risks associated with the new network.
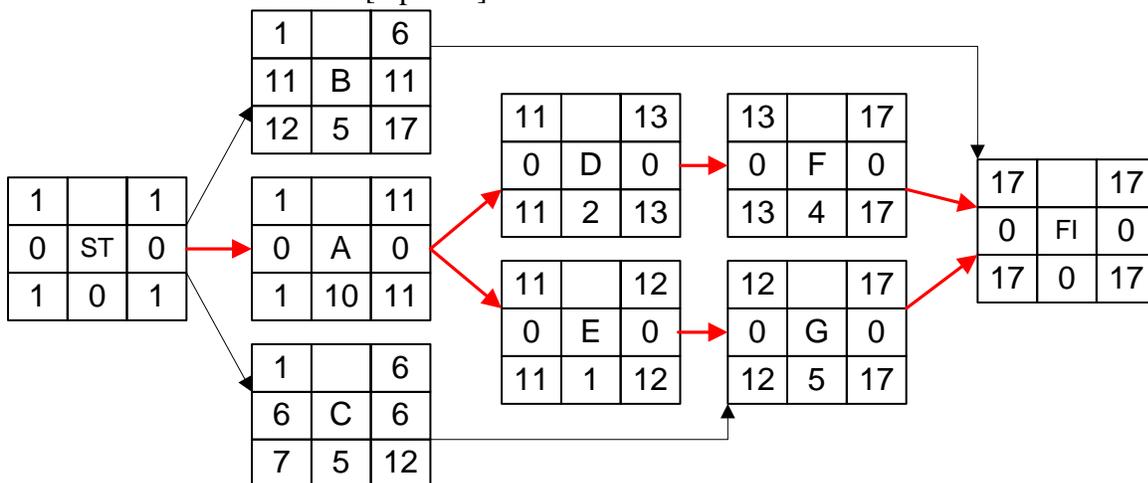
Question 6 [22 points]
A project has activities as shown in Table 6.1.

Table 6.1. Activity data

Activity	Duration	Predecessor	Resource per Day
A	10	-	2
B	5	-	5
C	5	-	3
D	2	A	2
E	1	A	3
F	4	D	2
G	5	C, E	4

6.a. Draw an AON network. Compute the ES, EF, LS, LF, TF, and FF. What is the critical path(s)? What are critical activities? [7 points]

The AON network is below [6 points]:

Note: Each wrong relationship or number will be deducted 1 point but total deductions should not greater than 6 points.
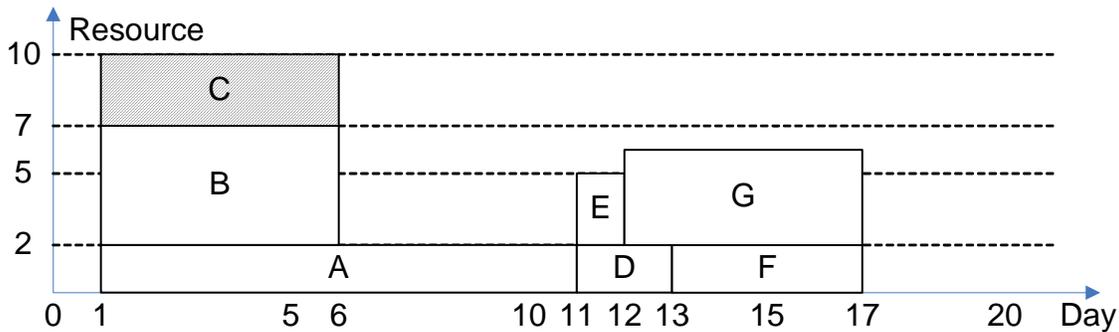
[1 point] Two critical paths:
Start – A – D – F – Finish
Start – A – E – G – Finish
Five critical activities: A, D, E, F, and G

6.b. Level the resources to a maximum of 7 units/day while keeping the project duration as short as possible. Do not split any activity or change any activity duration. [10 points]
The resource histogram before leveling is below [4 points]

[2 points] Activities B and C are non-critical activities. We need to consider changing their timing first. Observe the above histogram we can either start activity C right after B finishes or vice versa. Two new resource histograms are below [4 points]:
B starts right after C finishes:
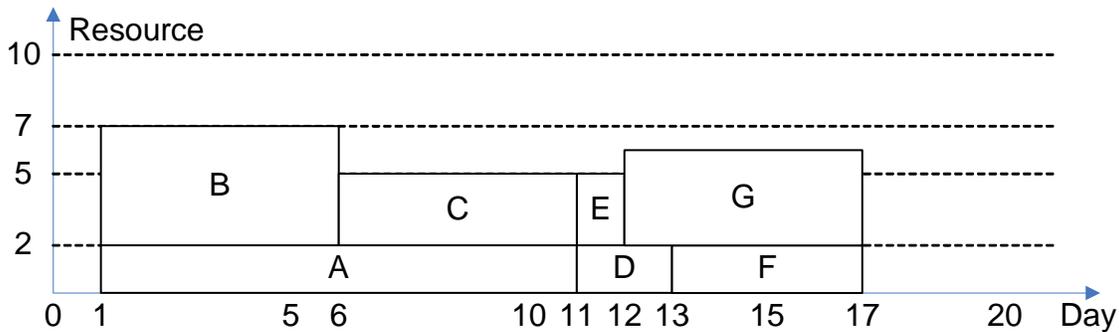
B starts right after C finishes:
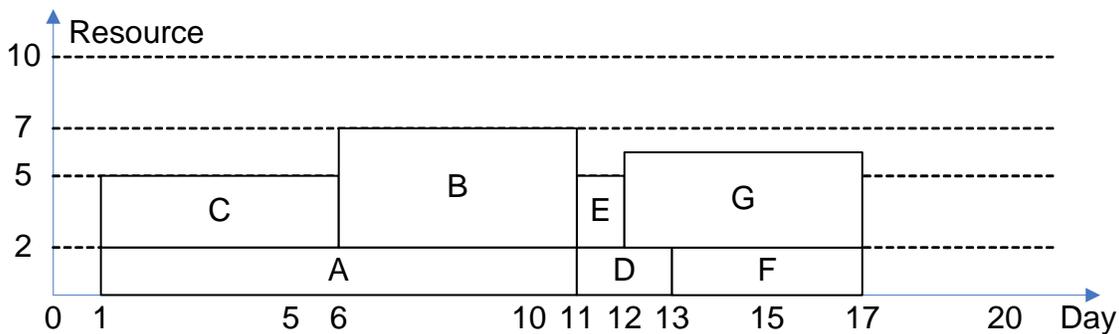
Note: If a student offers only one resource leveling solution, he/she will get 4 of 6 points. Otherwise, he/she will get 6 of 6 points.

6.c. After solving the resource leveling problem, identify the critical path(s) and discuss what makes it critical. [5 points]

After solving the resource leveling problem, all paths and activities in the network become critical. The original critical paths (Start – A – D – F – Finish and Start – A – E – G – Finish) are still critical due to the zero float of all activities (A, D, E, F, and G) in these paths. The other two paths Start – A – B – Finish and Start – A – C – G – Finish are also critical although activities B and C have positive total float. The reason is that we now cannot delay activities B or C without delaying the project duration. The current project duration is still 16 days.

Total Score: 100 points