EXAMINATION MARKING GUIDELINES YEAR OF STUDY: (Varies)

EXAM TITLE: Engineering Project Management DEC 2021

MARKS

Question 1 (Fred Bosché)

Part (a) (CPM):
(i)
The table under the Gantt chart (see next page) summarizes the resource requirements based on the initial programme.
Marks (3 marks): 3 marks for correct resource allocation; -1 mark for each error.

(ii)
One can see that, except for activities H and O, all other activities are on critical paths.

It appears that SC is over-allocated over 6 consecutive months, and EIC is over-allocated at two occasions, once for 10 months and one last time for 2 months.

To be able to address the over-allocation, one should look at first moving non-critical activities.
For SC, activity H only has a float of 2 months and this would not even reduce the overallocation.
For IEC the first 10-month overallocation involves two critical activities and the 2-month overallocation include one non-critical activity but its float doesn't enable reducing the over-allocation.

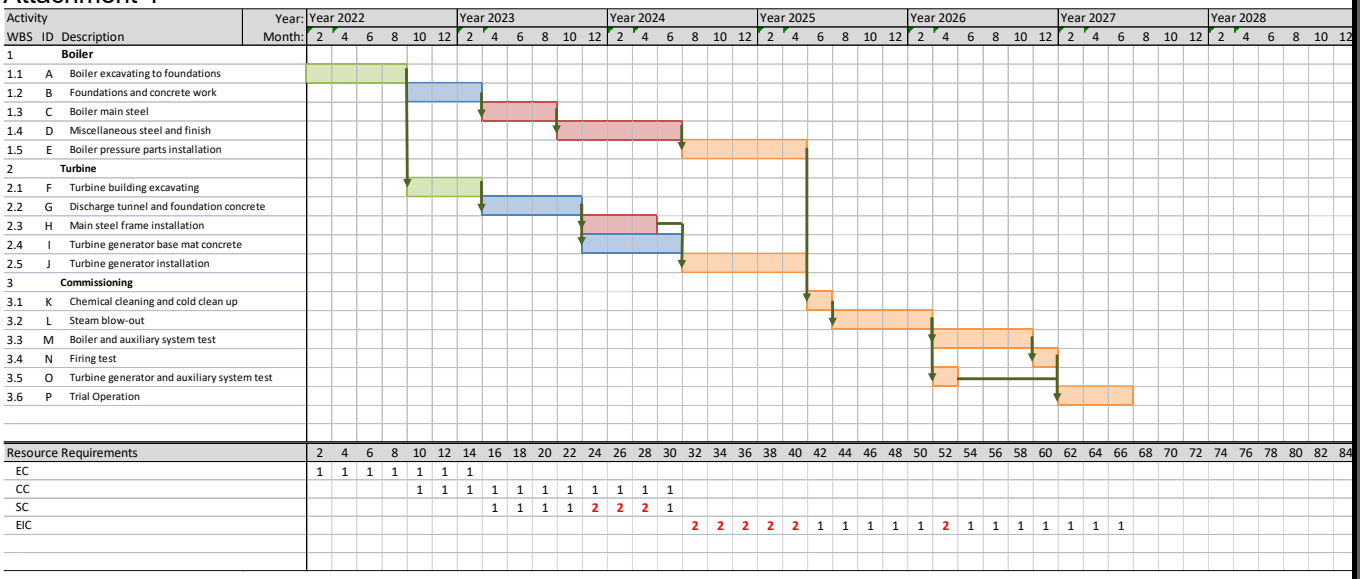
So, the only solution is now either to delay the project or hire additional resources to deal with the over-allocations. The decision between either option depends on their respective costs.
For SC, one can see that the monthly (overhead) cost of bringing one additional SC (£0.5 million) is higher than the monthly cost of delay (£0.4 million). So, the SC overallocation is best dealt with by delaying the project. For this, we can delay activity H to start in July 2024, which will delay J and all subsequent activities by 6 months.
For EIC, in contrast the monthly cost (overhead) cost of bringing one additional EIC (£0.3 million) is lower than the monthly cost of delay (£0.4 million). So, the EIC over-allocation is best dealt with by getting a second EIC for the two periods of 10 months and 2 months.

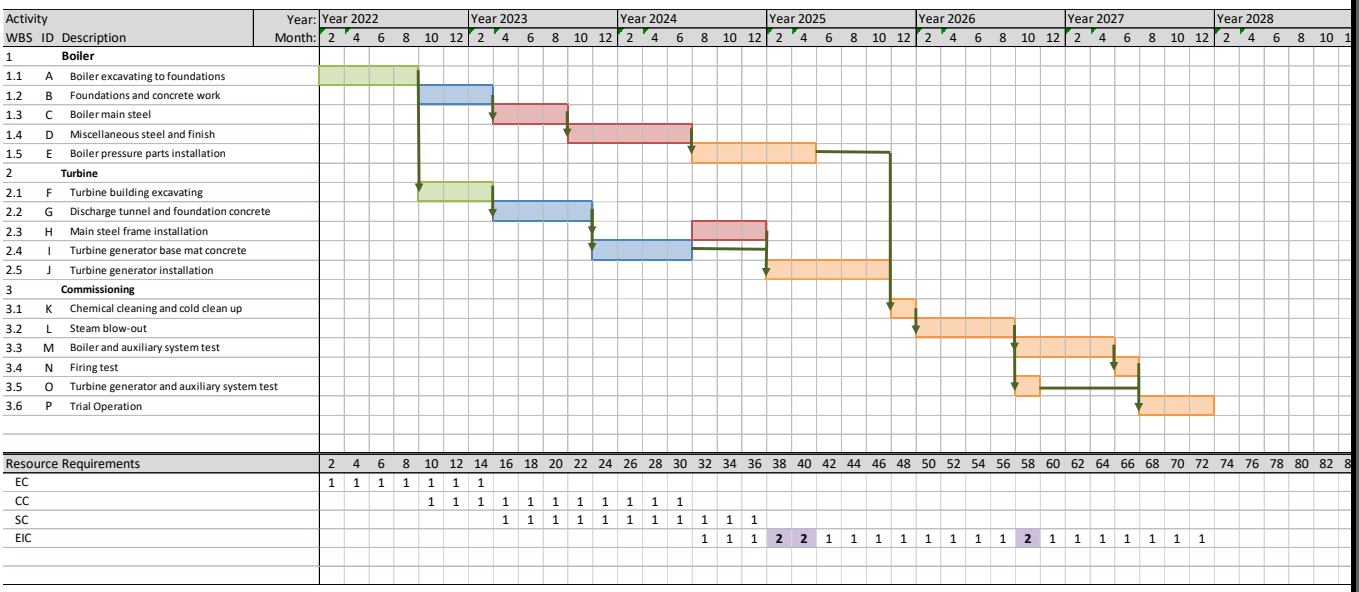
This solution is illustrated in the following graph.

Note, however, that for the first part, it is possible (although there is no information about the feasibility of this) to look at accelerating the activities conducted by EIC in order to make up for the 6 month delay, since the monthly (overhead) cost of bringing one additional EIC (£0.3 million) is lower than the monthly cost of delay (£0.4 million). This idea is fully acceptable.

Marks (15 marks):
An excellent answer (12+ marks) should identify all the over-allocations and also find that both over-allocations require the provision of extra funding, but one is best dealt with through project completion delay, while the other one is best dealt with through the provision of additional resources.
A good answer may have a small error from there.
If the student finds an answer that is correct but not optimal (i.e. delay project or additional resources) will be capped at ~60% (9 marks)
Any answer correct but based on an identification of resource requirements that renders the problem overly simple will be capped at ~50% (8 marks).
Any answer with a clear error of logic or understand of a Gantt chart cannot exceed ~40% (7 marks).

Attachment 1





Part (b) (MM vs EVA):
Milestone Monitoring (MM) is much easier to apply because it doesn't require tracking "Work Performed" continuously, but only assess performance at defined milestones. However, this means that no reliable performance assessment can be obtained in-between milestones. One must also pay attention to define very clear milestones.

EVA enable continuous measurement of performance, even between milestones. However, this requires the continuous measurement of "Work Performed", which is not easy to do at all and can be subjective.

A 50-60% answer will provide a partial assessment (e.g. clear benefits but unclear drawbacks for one of the methods).
A good answer will discuss the above.
An excellent answer may go beyond and maybe also highlight other issues (e.g. SPI values in EVA).
Marks (6 marks): 6 (3 for MM; 3 for EVA; -1.5 for any unclear/incomplete answer in each)

Part (c) (EVA)
This question is challenging. The correct answer is not long to express but reaching it requires careful analysis of the information provided.

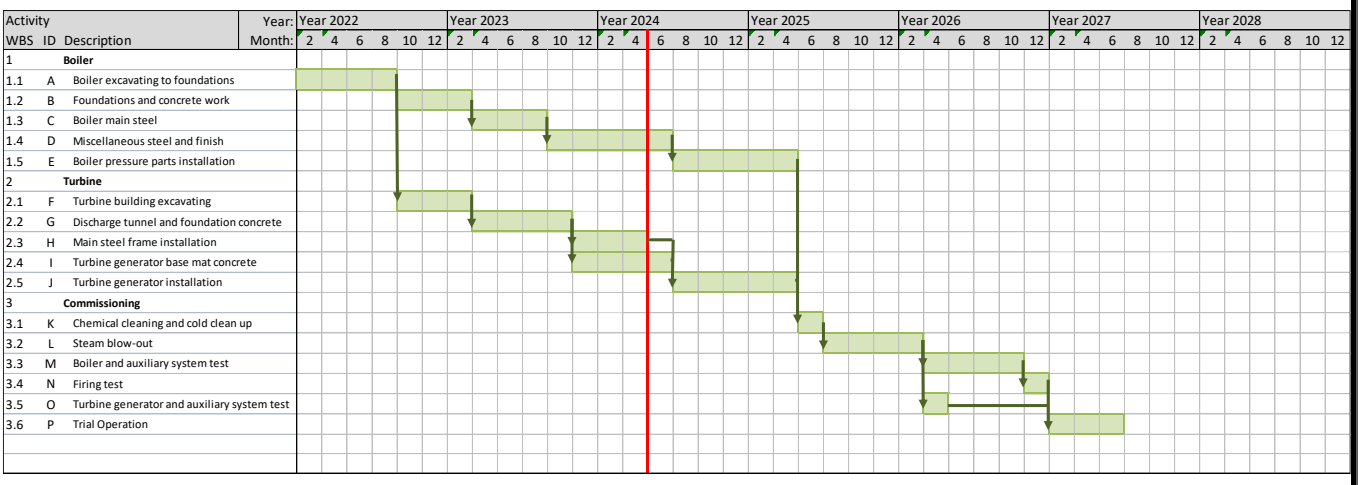
The Gantt chart on the last page highlights at which point (end of April 2024) the EVA table is obtained. It can be seen that, at that point, activity H should be completed, activity D should be approximately 80% completed, and activity I should be 75% completed. In fact, looking at the EVA table, the SPI for activities D and I is exactly 1.00, which is means they are exactly on time. Their CPI are >= 1.00, which means they are also doing well with regard to cost performance.
In contrast, activity H has SPI=0.85 and CPI=0.94. Both, and principally the first one, are worrying. However, two important observations should be made here. First, H is not on the critical. Therefore, it's SPI may not in fact result in a project delay. Besides, looking at the performance last month, it can be seen that the poor time performance seems not to be an on-going issue and there is thus a good likelihood that the activity will be completed within its float.
Overall, the SPI for the whole project is misleading and is more likely very close to 1.00. The only issue thus seems to be cost performance at 0.98. But, this is "just" 2% over-budget, and the project is only 30% complete. This means that the team should currently mainly focus on maintaining the tempo and look for ways to achieve small savings in the remainder of the project. To achieve a CPI of 1.00 at the end of the project, the CPI performance for the rest of the project only needs to be (307 – 93) / (307 -95.2) = 1.01, which is achievable.

Good and excellent answers will have noticed that H is not critical and thus it's SPI value is misleading.
An excellent answer will particularly detail its answer and maybe even discuss the required performance until the end of the project to achieve CPI = 1.00, or also suggest that the SPI value for the project should probably only consider activities that are neither critical nor at risk of becoming it. When doing so, the SPI value is 1.00.

Marks (16 marks): 4 overall cost and time performance; 8 time and cost performance of H; 2 time and cost performance of D; 2 time and cost performance of I.

Attachment 2: EVA Table (Question 2)
Note: Values are in millions of Pounds.

Activities			Budget	Actual %	Last month					Cumulative to Date						
WBS	ID	Description	(£m)	Complet	BCWS	EV	ACWP	SV	CV	BCWS	EV	ACWP	SV	CV	SPI	CPI
1		**Boiler**														
1.1	A	Boiler excavating to foundations	5	100%	0	0	0	0	0	5	5	6	0	-1	1.00	0.83
1.2	B	Foundations and concrete work	15	100%	0	0	0	0	0	15	15	14.5	0	0.5	1.00	1.03
1.3	C	Boiler main steel	20	100%	0	0	0	0	0	20	20	21	0	-1	1.00	0.95
1.4	D	Miscellaneous steel and finish	5	80%	1	0.9	1	-0.1	-0.1	4	4	4	0	0.1	1.00	1.03
1.5	E	Boiler pressure parts installation	80	0%	0	0	0	0	0	0	0	0	0	0	N/A	N/A
2		**Turbine**														
2.1	F	Turbine building excavating	5	100%	0	0	0	0	0	5	5	4.8	0	0.2	1.00	1.04
2.2	G	Discharge tunnel and foundation concrete	15	100%	0	0	0	0	0	15	15	15	0	0	1.00	1.00
2.3	H	Main steel frame installation	20	85%	3	3.2	3.2	0.2	0	20	17	18	-3	-1	0.85	0.94
2.4	I	Turbine generator base mat concrete	15	80%	4	4.2	4.1	0.2	0.1	12	12	12	0	0	1.00	1.00
2.5	J	Turbine generator installation	90	0%	0	0	0	0	0	0	0	0	0	0	N/A	N/A
3		**Commissioning**														
3.1	K	Chemical cleaning and cold clean up	2	0%	0	0	0	0	0	0	0	0	0	0	N/A	N/A
3.2	L	Steam blow-out	15	0%	0	0	0	0	0	0	0	0	0	0	N/A	N/A
3.3	M	Boiler and auxiliary system test	10	0%	0	0	0	0	0	0	0	0	0	0	N/A	N/A
3.4	N	Firing test	2	0%	0	0	0	0	0	0	0	0	0	0	N/A	N/A
3.5	O	Turbine generator and auxiliary system test	2	0%	0	0	0	0	0	0	0	0	0	0	N/A	N/A
3.6	P	Trial Operation	6	0%	0	0	0	0	0	0	0	0	0	0	N/A	N/A
		Total:	**307**	**30%**	**8**	**8.3**	**8.3**	**0.3**	**0.0**	**96**	**93**	**95.2**	**-3**	**-2.2**	**0.97**	**0.98**



Question 2 (Simon Smith)

Part (a)

George is referring here to the concept of **innovation**. He may not have called it that in the 1960s but innovation in its simplest terms is the introduction of **improvement**. By asking his engineers to consider the limits of current practice he is asking them to understand **what difference** needs to be made in the techniques that are currently employed in order to bring about this desired improvement. He is also, in the next question, asking his engineers to be able to quantify or at least communicate the aspects of the new approaches which might lead to these improvements. By doing so he allows the engineers to be able to focus on those aspects of their projects.

Engineering projects are **unique** or 'one offs' but that does not mean they are entities which sit alone with no influence on what comes next. The techniques and methods deployed in one project will likely be also used in **future project**s so it is important that engineers are able to identify **what did not** work in past projects so well – and also **identify what did work well**. This knowledge can then be used in future engineering projects to provide a better project than would not otherwise be the case. This might be better in a number of ways – quality, cost, time, sustainability, safety etc.

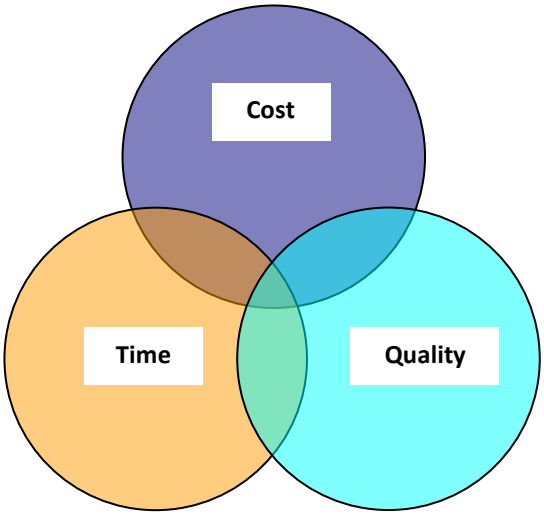
This answer requires knowledge and thinking beyond what was provided and discussed in the course. I will therefore accept a **range of different answers** which allude to the same concept, which is that of **lessons learned** or **learning from failure** or **organisational learning** or **best practice.** It is a commonly understood concept – essentially requiring the capture of previous knowledge ("How is it done today"), identifying its limitations ("what are the limits of current practice?"); what can be done differently ("What's new in your approach?") and recognising how this can lead to improvements ("why do you think it will be successful?")

10 marks

Part (b)

This part is a different framed question to one which has appeared in a number of previous papers, and one which considers the compromises of time, coast and quality. This is well covered in the early part of the course; the following notes apply:

The management of projects is all about dealing with compromises. A traditional view of a project is that there are three aspects of a project which the Project Manager is striving to maintain, but each are dependent upon each other to some degree: Cost, time and Quality.



The implication here is that, for example, to improve the project costs (finish within budget) may result in a detriment to project quality (cheaper materials). Or, for example, to improve on the project time (finish early) may result in an increase in project cost (pay for overtime).

This simple three way system is extended for almost all projects to include the aspects of safety and environment. The implication being that any project decision on saving on cost, time or quality will have an implication on safety and the environment: the cheapest project will not be the safest project.

The importance of each of these five attributes on a specific project will vary. For example, the organisers of the Olympic Games would place a higher priority upon *time* than they would on *cost*, (and possibly quality?) as the stadium has to be completed by the event date.

10 marks

Part (c)

i. This is very well covered in the early part of the course and also in the first seminar. I will be looking for an understanding of potentially the following concepts, though this is not an exhaustive list:

- That demand leads to innovation
- That demand allows a financial case to be made,
- That demand allows the developers to explore why a project is needed
- That it enables a quantification of what a successful project will look like
- That it can bring about public and funders acceptance of the project
- That it might lead to quicker approval

ii. The client is ultimately responsible – they own the project and are in the best position to identify why a project is needed. But they should be provided with advice as necessary, so while being responsible they may not actually do the identification.

iii. Not identifying project demand properly can lead to a lack of success in the delivery of the project simply as it will not be known when that demand is fulfilled.

iv. Not delivering demand is very damaging – the project is then perceived as a failure on many levels. For these last two parts students will be expected to provide detailed answers – the concepts are straightforward but full understanding is demonstrated through pertinent examples. Obvious ones from the course are the Edinburgh Trams and the Queensferry crossing but as stated in the exam paper itself greater value will be provided if students' own examples are given.

10 marks

Question 3 (Simon Smith)
Part (a)

i. There might be a distinction here between *parties* to a project and *stakeholders*. If students identify this then further marks might be gained. But the five key parties identified in the lectures are:

a. Promoter/client:

- Aims:
- To obtain the best economic solution to a problem whilst
- Bearing the safety of all who work on the project, at any stage in its cycle, in mind without
- Compromising unnecessarily the environment in which the project takes place
- Responsibilities:
- To identify the needs and satisfy itself that the project will serve these needs
- To define the nature and functions of the project
- To obtain any statutory powers necessary for the construction and operation of the project
- To (usually) operate the project at completion; and
- To (usually) find the money to pay for the design and construction work.

b. Project management team:

- to develop the promoter's requirements by using PMT experience to achieve the optimal solution, and
- to manage the finally defined project on behalf of the client to ensure that the objectives advised to the client as being achievable are actually implemented.

c. Designer

- To undertake feasibility studies on the project and report and advise the promoter on its findings
- To develop design options and advise the promoter
- To obtain any necessary approvals and consents
- To define the next stages in the project
- To prepare contract documents such as specifications, bills of quantities and contract drawings
- To advise the promoter on the correct choice of contractor

- To technically supervise the construction work
- To measure, value and authorise payment for the completed works

d. Contractor

- To appoint staff and mobilise labour, plant and materials
- To design the works (if required under the contract)
- To (usually) insure the construction works until completion
- To provide a plan and programme of construction for approval by the promoter or project manager
- To design and construct temporary works
- To supervise sub-contractors

e. Operating company

- To run the project
- Meet the needs of the users
- Maintain the asset
- Identify problems
- Obtain funding for its continued sustainability

ii. Many examples can be provided here. Good ones from the lectures are rail projects where design, operation, client might be the same; hospitals; highway projects. In the seminar on this a good example was 'changing a lightbulb' where the class decided all five roles were fulfilled by one person.

10 marks

Part (b)

i. The main point here is that if there is little information – and at the start of the project there will not be much information – then the accuracy of the project will suffer. The most accurate estimating methods require detailed data and the quantity of data naturally increases as the project and its design develops.

ii. There are many cognitive biases which might affect a lot of decision making in project management. The key one to be identified here is optimism bias whereby the cost and time to do something is considered to be lower the more confident someone is of being successful. The ones mentioned in the lectures also include "Insufficient judgement" and "Overconfidence in Estimation of Probabilities" but there are many others including "Sunk-Cost Effect" and "Planning Fallacy"

iii. There ideally there will be an appreciation that this question can be answered from different viewpoints. The consequence of a low estimate may make project funding later on difficult, particularly if decisions have been made binding to a certain cost level. A good example to quote here will be HS2 whereby the project's escalating cost is proving to be more and more difficult to justify. Better students might make a connection to the sunk-cost bias here, and there is a very good paper provided on the course Learn site which discusses the consequences of 'escalation of commitment' on the Holyrood project. But if one's viewpoint is that a low estimate will lead to a greater chance of project approval (i.e. a positive effect) then the concept of strategic misrepresentation comes in. I would not expect examples here on projects that have suffered from this, though students may provide them

10 marks

Part (c) (this part requires understanding of the "Financial Resources part of the course")

i. This question can be answered simply with a definition of surplus and profit, but ideally it also needs to show understanding of expenditure and income. As money flows out of a company (be it promoter or contractor) money also flows in as payment for work undertaken. If any organisation is to survive and grow its income must be greater than its expenditure – it must receive a higher sum of money for an element of work than its cost. It may be that the *actual* cost incurred may be different from the *estimated* cost, in which case the profit will be different from that anticipated. The price will invariably remain the same so often the profitability is indicated by the *surplus* – quite simply the difference between the expenditure and the income. A negative surplus indicates the actual costs are greater than the price received.

ii. The provision of work and services rarely occurs at the same time as an exchange of money. In the same way as someone who has a job rarely gets paid in advance a contractor will get paid by the promoter some time after an element of work is completed. The contractor itself will pay its labour force, material suppliers and subcontractors in arrears. In financial terms when work or service is provided by one of the areas of cost, a *liability* is incurred by the receiver of that work or service. After a period of time (that is negotiated and indicated by the contract between these two parties) a payment is made and the *liability* becomes an *expenditure*. The supplier of the work or service has provided some value but will not get paid for it for the (agreed) period of time. The supplier has generated earnings – this earning becomes income once payment is made. This is important because while the money is paid eventually, and as long as everyone's income is greater than its expenditure they will all be happy, the time delay between liability and expenditure will impact on one party more than another – the client prefers a long time between liability and expenditure which the contractor prefers a shorter time.

iii. Retention is simply where the client retains a small fraction of the total payment – typically 5% - to cover a guarantee that the contractor will honour the defects correction period. Once a pre-agreed period of time has elapsed then the client releases this money. It is contentious because 5% is often more than the contractor's project profit and if all of their profit is tied up in retention that can affect their financial situation and cashflow. There is also a growing understanding of the power of trust in a contractual arrangement – better students will allude to this.

10 marks

END OF PAPER