Sample Questions
REVISED FIRST CLASS PARTS A1, A2, AND A3

(NOTE: these questions are intended as representations of the style of questions that may appear on examinations. They are not intended as study material and, as such, may not be in line with any current examination syllabus)

1. A belt pulley is 3 ft. in diameter and rotates at 250 rpm. The belt which is 5 ins. wide makes an angle of contact of 190° over the pulley.

   If the coefficient of friction between the belt and the pulley is 0.28 and the maximum tension is 495 lbs;

   Determine the power which can be transmitted by the belt.

   GIVEN:

$$\ln\left(\frac{F_1}{F_2}\right) = \mu\theta$$

   Where: μ=coefficient of friction
   θ=angle of wrap
   e=0.43
   F_1=force in tight side
   F_2=force in slack side

2. A short steel tube is rigidly fitted over a copper bar. The lengths of the tube and the bar are exactly equal, and their cross-sectional areas are each 2000 mm^2. This combined bar carries an axial load of 17.5 tonnes.

   Determine the loads carried by the steel and copper respectively.

   E_{steel} = 210 x 10^3 MPa and E_{copper} = 112 x 10^3 Mpa.

3. A tank contains water, the free surface of which is maintained constantly at 3 feet 6 inches above the centre of a sharp edged orifice in the side of the tank. The water flows through the orifice into a second tank which has a capacity of 600 gallons.

   Determine the length of time it will take to fill the second tank from the first tank.

   Note: Diameter of orifice = 1.25 inches
   Co-efficient of velocity = 0.98
   Co-efficient of area = 0.63

4. A seamless pipe 170 mm o.d. and 148 mm i.d. of SA 335 Pl material is welded into a shell as shown in Fig. P.G. 36(b) ASME Section I. The shell is made from SA 516-70 material with an i.d. of 1 metre, a thickness of 15 mm and a joint efficiency of 1. If the maximum working pressure is 1800 kPa;

   Prove that the ASME Code requirements are being met.

   Assume the welding meets the minimum requirements.

5. A steam separator has the following specifications:

Design Pressure -	350 kPa
Design Temperature -	160o C
Inside diameter -	760 mm
Length tangent to tangent -	2 metres
Formed seamless heads -	2:1 semi elliptical
Shell material -	SA 285 B
Shell thickness -	9.5 mm
Head material-	SA 285 B
Head thickness-	9.5 mm
Corrosion allowance -	3.2 mm
Joint efficiency -	90%

Show by calculation whether or not the separator design conforms to ASME Section 1.

N.P.S. Nozzles			
Number	**Size**	**Schedule**	**Material**
2	51 mm	160	A-53B
3	203 mm	XH	A-53B

ANSI Nozzle				
Number	**Size**	**Schedule**	**Type**	**Flange Material**
2	51 mm	300	RFWN	SA 181 Gr 1
3	203 mm	150	RFWN	SA 181 Gr 1

6. The output of a turbo-generator is 7,500 kW. The electrical efficiency is 94% neglecting all other losses. 1,000 m^3 of air at 21°C per minute are blown through the windings at a pressure of 150 mm of water. The windings are kept at 55°C.

What is the difference in temperature between the windings and the final temperature of the air?

NOTE: 1 m^3 of air at 0°C and at a pressure equal to a head of 10.36 m of water is 1.28 kg, and CP air = 1.008 kJ/kg.

7. A gas occupies 0.34 m^3 at an absolute pressure of 103.4 kPa and 38°C

   Find the final volume, temperature and work done on the gas when it is compressed to 1,655 kPa absolute:

   (a) according to the law $PV^{1.3}$ = constant;

   (b) adiabatically, take CV = 0.876 kJ/kgK , CP = 1.227 kJ/kgK

8. The cylinder of a steam engine contains 0.02 m^3 of dry saturated steam at 800 kPa. If the steam undergoes polytropic expansion to a pressure of 350 kPa and a volume of 0.043 m^3,

   Calculate the:
   (a) mass of steam in the cylinder,
   (b) final dryness fraction,
   (c) index of expansion,
   (d) change in internal energy,
   (e) work energy transferred.

9. A coal has the following analysis by mass.

Carbon	=	83.4%
Hydrogen	=	4.9%
Oxygen	=	3.7%
Nitrogen	=	1.1%
Sulfur	=	0.4%
Ash	=	6.5%

		100%

   Calculate the:
   (a) weight of air required for the complete combustion of the coal using the weight method

   (b) volume of air required for the complete combustion of the coal using the mol method

   Note: assume the volume of a mol of air to be 107308.02 litres.

10. In a boiler plant consisting of an economizer, evaporator, and superheater, steam is generated at a pressure of 1,000 kPa at a rate of 6,800 kg/h. The temperatures of the feedwater entering and leaving the economizer are 45° C and 170°C respectively. At entry to the superheater the dryness fraction of the steam is 0.96 and at the outlet the temperature is 250°C. The boiler burns coal at the rate of 700 kg/h, the calorific value of the coal is 31,500 kJ/kg and air is supplied at the rate of 17 kg/kg fuel.

    (a) Calculate the equivalent evaporation of the boiler plant per kg fuel from and at 100 °C.

    (b) If the temperature of the flue gases at entry to the economizer is 480 °C, calculate the outlet flue gas temperature.

    For flue gases CP = 1.045 kJ/kgK

    (c) Draw up an energy balance (kJ/kg coal) assuming the atmospheric temperature is 21 °C.

11. (a) Discuss in detail the justifications for installing a steaming economizer in a plant and the factors that would limit its size

    (b) Explain where you would install an economizer in a plant.

    (c) What steps would you take to retard the corrosion rate on the external and internal surfaces of an economizer?

12. (a) Why are orifices installed in the inlets of waterwall circuits of controlled circulation boilers?

    (b) Sketch and describe how these orifices are protected from being plugged.

13. The construction of a new boiler has just been completed at your plant. Explain in detail how you would conduct an inspection on this boiler before you filled the boiler with water to boil it out.

14. (a) Discuss the factors you would consider in selecting the following types of boiler-feedwater regulators and state under what circumstances each would be employed:
    (i) single element;
    (ii) two element;
    (iii) three element.

    (b) With the aid of a single line sketch, describe a three element boiler-feedwater regulator and explain its principle of operation.

15. (a) Describe the preparation you would make to prevent damage to fittings and equipment during a hydrostatic test on pressure piping.

    (b) Discuss the precautions you would take to prevent over pressure due to thermo-expansion during a hydrostatic test on pressure piping.

    (c) State the minimum holding time for a hydrostatic test on pressure piping.

    (d) Name three conditions where it is permissible to carry out a pneumatic leak test on pressure piping.

    (e) Explain the procedure for applying pressure in a pneumatic leak test on pressure piping.

    (f) State the minimum holding time for a pneumatic test on pressure piping.

16. (a) Give the advantage the O_2 recorder has over the CO_2 recorder.

    (b) With the aid of a sketch, describe clearly the principle of operation of an O_2 recorder for flue gas analysis.

17. (a) Sketch an ash handling system suitable for a large pulverized coal fired plant using both the hydraulic and pneumatic method.

    (b) Describe the operation of the system.

18. A fan develops a static pressure of 75 mm water and a velocity pressure of 10 mm water. The input or shaft power is 650 kW and the static efficiency is 80%.

    Calculate the:
    (a) the capacity of the fan;

    (b) the mechanical efficiency of the fan.

19. With reference to steam turbines, discuss in detail the following:
    (a) downtime and wet end corrosion;

    (b) erosion;

    (c) stress corrosion cracking.

20. Give a detailed description of the installation of a pump in power plant. Include the precautions which must be taken both during installation and before operation of the pump when installed.