Physics Mock Test No. 1

IJSO Theory Mock Test

Answer Sheet

Problem 1 – Airborne Aircraft Carrier

Part A – Takeoff and Landing

A1. Find the minimum take-off speed of the aircraft (relative to Earth) at its maximum weight capacity.

Calculation:

A2. Find how long the runway should be in order to reach the minimum takeoff velocity calculated in A1.

Calculation:

A3. Calculate the new takeoff velocity needed if each thruster provides maximum power.

Calculation:

A4. Calculate the new runway length in the same conditions as A2.

Calculation:

A5. Find how long a runway should be in order for the craft to successfully land.

Calculation:

Part B – Fuel source

B1. Find v.

Calculation:

B2. Find the power exerted by one engine if the airplane has 4 engines.

Calculation:

B3. Find the amount of fuel needed to keep this craft moving at a fixed altitude for 40 days.

Calculation:

B4. Find the mass of the uranium sample needed to keep this craft flying for 40 days.

Calculation:

B5. Which fuel source is more suitable?

- Airplane fuel
- Uranium sample

Part C – Density of the Airplane

C1. What is the mass percent composition of an alloy of aluminum and titanium having a density of $2.90\ g / cm^3$?

Calculation:

Part D – Altitude

D1. Find the speed of the plane.

Calculation:

Extra space for Problem 1

Problem 2 – An experimental analysis of star luminosity

A. Find a formula for the luminosity per unit area of the star M, using the conservation of energy and assuming a spherically symmetric distribution of the energy.

Calculation:

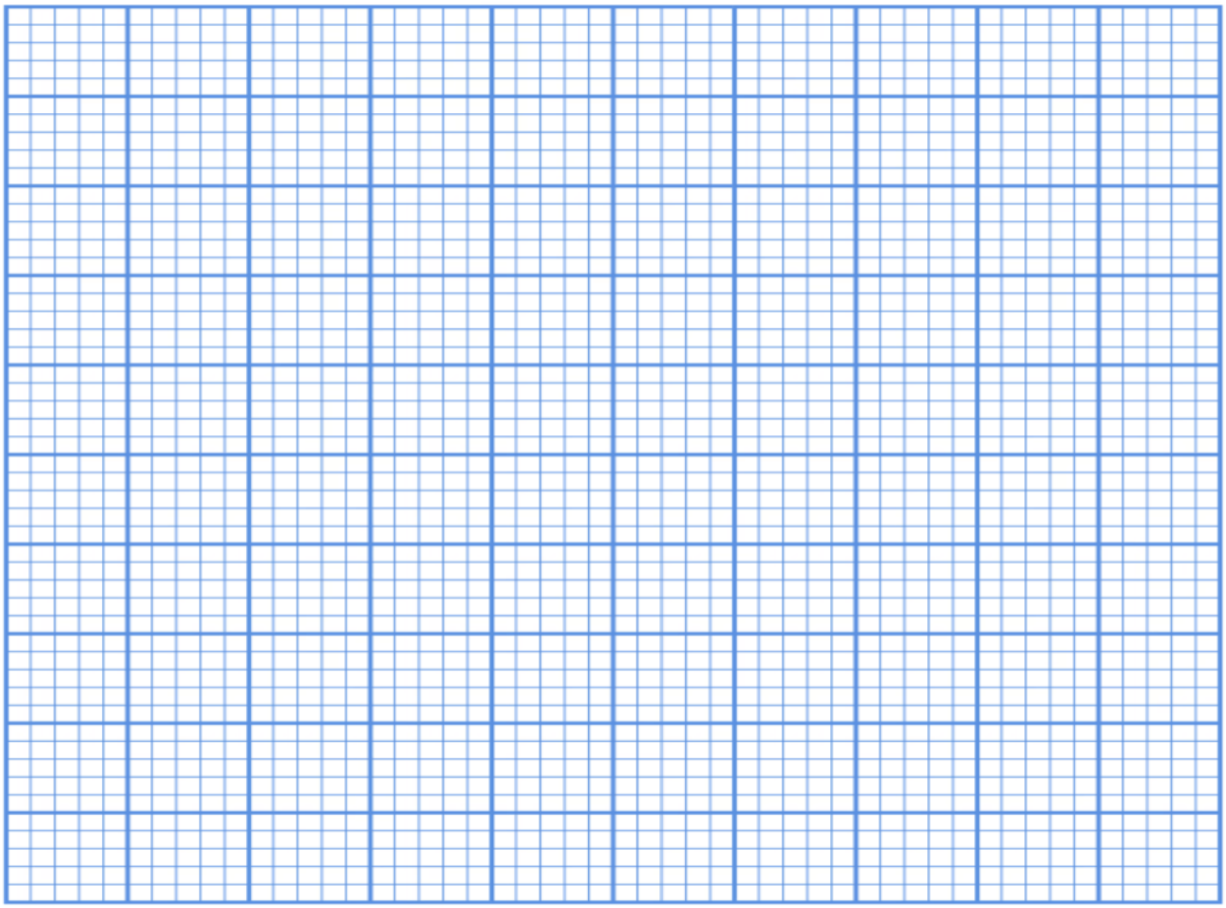
B. Fill in the following table:

Star	δ (rad)	d (m)	R (m)	M ($\frac{W}{m^2}$)
Arcturus				
Vega				
Sirius A				
Dubhe				
Procyon				

Extra space:

C. On a sheet of graph paper, graph ln M as a function of ln T.

Star	ln M	ln T
Arcturus		
Vega		
Sirius A		
Dubhe		
Procyon		



D. Using the graph, find the value of n.

Calculation:

E. Using the found value of n, calculate the value of σ for each of the stars. Calculate the mean value.

Calculation:

Extra space for problem 2

Problem 3 – Climate Physics

Part A – Modelling cloud formation

A1. What phenomenon takes place when clouds form?

- ☐ Vaporization
- ☐ Sublimation
- ☐ Condensation
- ☐ De-sublimation (= deposition)

A2. Fill the following table:

Calculation:

$T = T_0 - h\Gamma$

h/km	T/K
0.5	
1.0	
1.5	
2.0	
2.5	
3.0	
3.5	

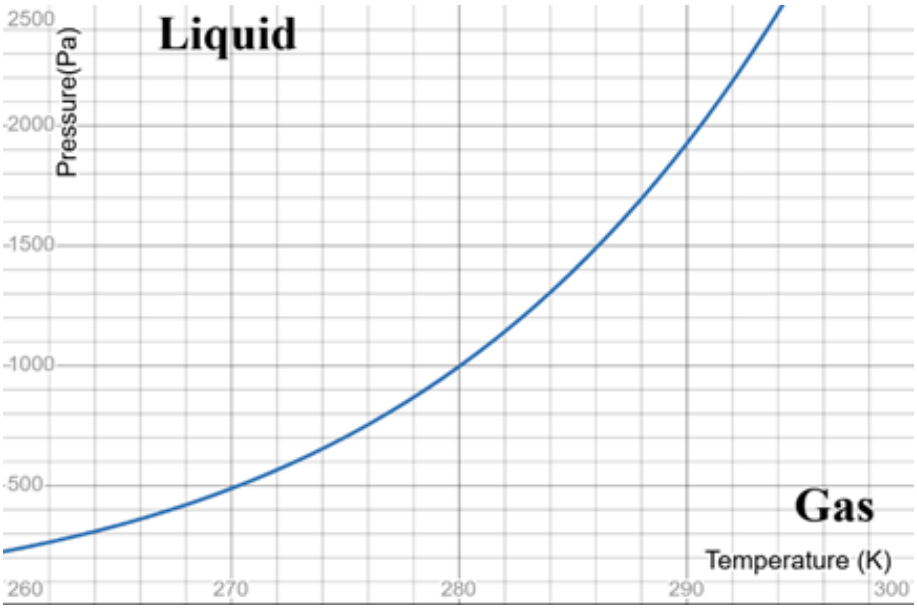
A3. Fill the following table with values of the partial pressure of water, knowing that the partial pressure of a gas in a mixture is directly proportional to its mole fraction:

h/km	P_{H_2O} / Pa
0.0	
0.5	
1.0	
1.5	
2.0	
2.5	
3.0	
3.5	

Extra space:

A4. On the phase diagram, plot each of the found (T, P_{H2O}) points. It might be useful to fill the following table (no points will be deducted for not filling it out):

h/km	T/K	P_{H_2O}/Pa
0.0		
0.5		
1.0		
1.5		
2.0		
2.5		
3.0		
3.5		



A5. On the phase diagram, trace a curve going through all the points drawn in part A4.

A6. What is the temperature at the height where clouds are expected to form? Using that, at what height do you expect clouds to form?

Calculation:

Extra Space:

Part B – Cloud electrification

B1. Consider two neutral clouds, after a frictional contact between them, they will end up being charged, what type of charge will each cloud have?

- ☐ Both Positive
- ☐ Both Negative
- ☐ One positive and one negative

B2. Calculate the new charge of cloud 1 and the new charge of cloud 2.

Calculation:

B3. The electric field due to cloud 1 on the ground, in a point right below it.

Calculation:

B4. The electric potential due to cloud 1 on the same point.

Calculation:

B5. Despite the potential difference between a cloud and the ground, we cannot assure that a lightning strike will actually occur, what is the best explanation for that?

- ☐ The potential difference is very small
- ☐ The air acts as an insulator, making the flow of electric charge difficult
- ☐ There needs to be a highly charged tall object on the ground
- ☐ Clouds quickly go through a discharge.

Part C – A different model for thunderstorms

C1. Assuming that air has the same electrical permittivity as vacuum, find the capacitance of the system formed by the cloud and the ground under it.

Calculation:

C2. If the cloud is charged with Q = +100C, find the potential difference between the ground and the cloud.

Calculation:

C3. What value will the new potential difference between the ground and the cloud have?

Calculation:

Extra space for problem 3