of SUN

SOLAR CALCULATION

CALCULATION of TOTAL SOLAR POWER RECEIVED BY AREA of COLLECTOR

$$\boxed{P = G \times A}$$

G = IRRADIANCE (W/m^2)

A = COLLECTOR AREA (m^2)

SOLAR POWER ON ROOF

pb CALCULATE THE SOLAR POWER ARRIVING ON 10 sqm OF ROOF AREA IF THE IRRADIANCE PERPENDICULAR TO THE ROOF IS $1000\, W/m^2$

$$P = G \times A$$

$$= 1000 \times 10 = 10{,}000\,W = 10\,kW$$

TOTAL SOLAR ENERGY RECEIVED BY AN AREA OVER A PERIOD OF TIME

$$E = H \times A$$

$$= G \times t \times A$$

E = SOLAR ENERGY (J)

H = IRRADIATION (J/m^2)

G = IRRADIANCE (W/m^2)

A = COLLECTOR AREA (m^2)

t = TIME (HR)

pb

pb CALCULATE THE DAILY SOLAR ENERGY RECEIVED BY A STANDARD HOT WATER COLLECTOR OF DIMENSION 1m BY 2m IN A LOCATION WHICH RECEIVES 24 MJ/m^2 DAY

$$E = H \times A$$

$$= 24 \, (1 \times 2)$$

$$= 48 \text{ MJ}$$

ENERGY COLLECTED BY SOLAR WATER HEATER

pb CALCULATE THE SOLAR ENERGY RECEIVED BY A STANDARD HOT WATER COLLECTOR OF DIMENSION 1m BY 2m OVER ONE HOUR AROUND NOON. IF THE IRRADIANCE STAYS FAIRLY CONSTANT AT ABOUT 800 W/m^2.

$G = 800$ $\quad A = 1 \times 2 = 2m^2$ $\quad t = 1 \text{ HR} = 3600S$

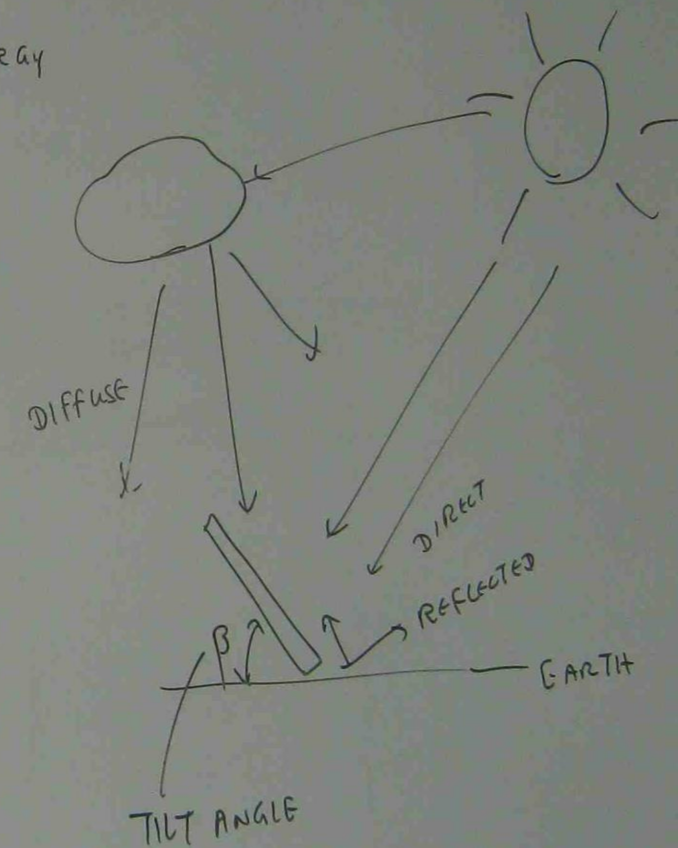
$$E = G \times A \times t = 800 \times 2 \times 3600 = 5760{,}000 \text{ J}$$

$$= 5.76 \text{ MJ}$$

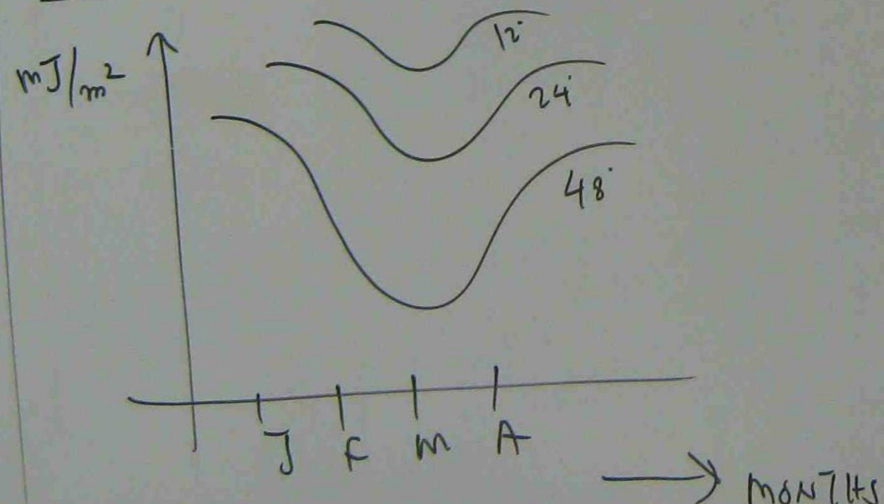
SOLAR CONSTANT

THE SOLAR CONSTANT REFERS TO THE AMOUNT OF SOLAR ENERGY RECEIVED ON A PLANE PERPENDICULAR TO THE SUN'S RAYS WHILE POSITIONED AT AVERAGE EARTH DISTANCE

AVERAGE	MAXIMUM	MINIMUM
1367	1412	1322



VARIATION OF SOLAR ENERGY



TILT ANGLE

LOAD VARIATION	FOR LATITUDE < 25°	FOR LATITUDE > 25°
LOAD IS FAIRLY CONSTANT THROUGHOUT YEAR (OR) HAS BOTH SUMMER AND WINTER PEAKS	L	L → L + 5°
MAXIMUM LOAD IN SUMMER	L − 5	L → L − 5
MAXIMUM LOAD IN WINTER	L + 5	L+10 → L+15

L = LATITUDE ANGLE

TILT ANGLE SHOULD NEVER BE LESS THAN 10° TO ALLOW SELF CLEANING.

CLEAR DAY FACING SUN (PEAK SUN)

IRRADIANCE = 1000 W/m²

MOST PLACES IN AUSTRALIA, AVERAGE DAILY SOLAR IRRADIATION 3 kWh/m² → 6 kWh/m²

SOLAR CONSTANT 1367 W/m²

SOLAR WATER PUMP CALCULATION

pb — SUCTION HEAD = 2.5
DELIVERY HEAD = 8.1

FRICTION — SUCTION = 0.24
DELIVERY = 4.8

REQUIRED BACK PRESSURE = 1.5

CALCULATE (a) TOTAL HEAD
(b) NPSHA BY USING THE FOLLOWING DATA TABLES

ALTITUDE (m)	HEAD (m of WATER)
0	10.33
100	10.30
200	10
300	9.97
400	9.85
500	9.73
600	9.61
700	9.5
800	9.38
900	9.37
1000	9.16

HEAD VS ALTITUDE

TEMPERATURE (°C)	VAPOUR PRESSURE (m)	TEMPERATURE (°C)	VAPOUR PRESSURE (m)
15	0.174	26	0.343
16	0.185	27	0.363
17	0.197	28	0.385
18	0.210	29	0.408
19	0.224	30	0.432
20	0.238	31	0.459
21	0.253	32	0.485
22	0.268	33	0.511
25	0.323	35	0.575

m^2

(c) FROM THE CHART, 3 L/S WATER FLOWS, 17.1 m WATER HEAD AND EFFICIENCY 55%, CALCULATE INPUT POWER

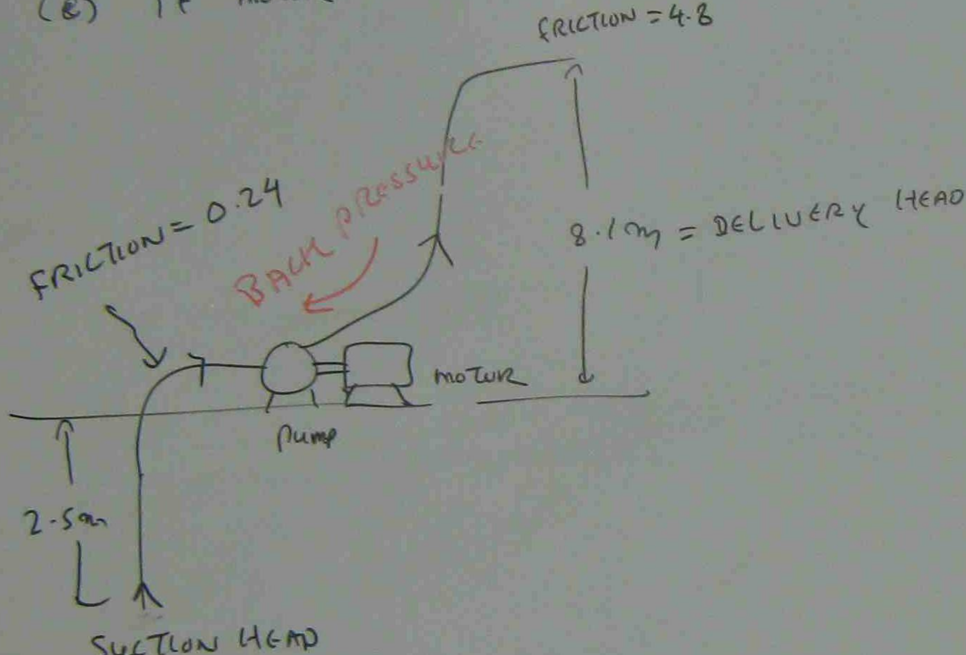
(d) IF SHAFT EFFICIENCY IS 95% CALCULATE SHAFT POWER

(e) IF MOTOR EFFICIENCY IS 78.6% CALCULATE INPUT ELECTRICAL POWER

NPSHA =

=

=



TOTAL PUMP HEAD = SUCTION HEAD + FRICTION + DELIVERY HEAD + FRICTION + BACK PRESSURE

$$= 2.5 + 0.24 + 8.1 + 4.8 + 1.5$$

$$= 17.1\,m$$

NPSHA = max head of water − (vapour pressure 25c + suction head + suction friction)

= 9.16 − (0.323 + 2.5 + 0.24)

= 6.1m SELECT THE PUMP WHICH IS GREATER THAN NPSHA

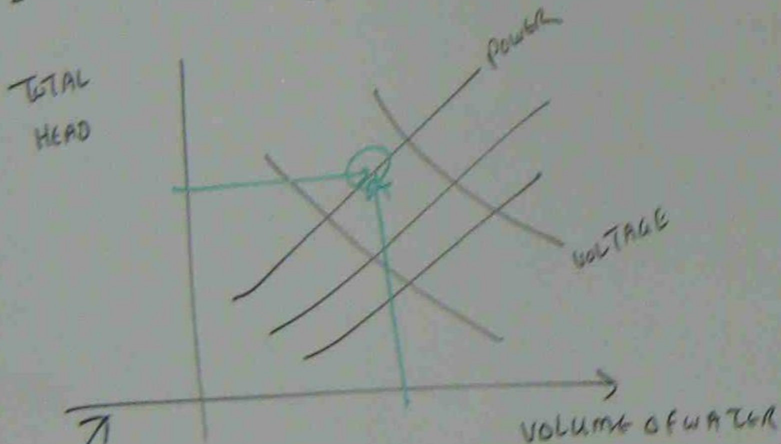
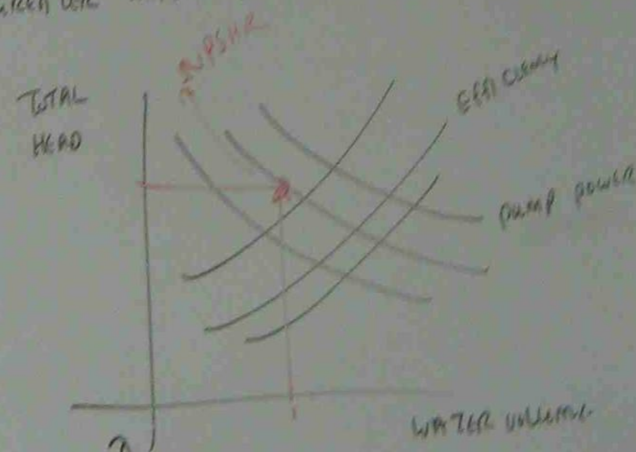


TABLE – PUMP POWER



NPSHR

CHECK NPSHR

(c) $P_{IN} = \dfrac{mgh}{\text{pump efficiency}} = \dfrac{3\,L/s \times 9.81 \times 17.1}{0.55} = 915\,W$ (motor power)

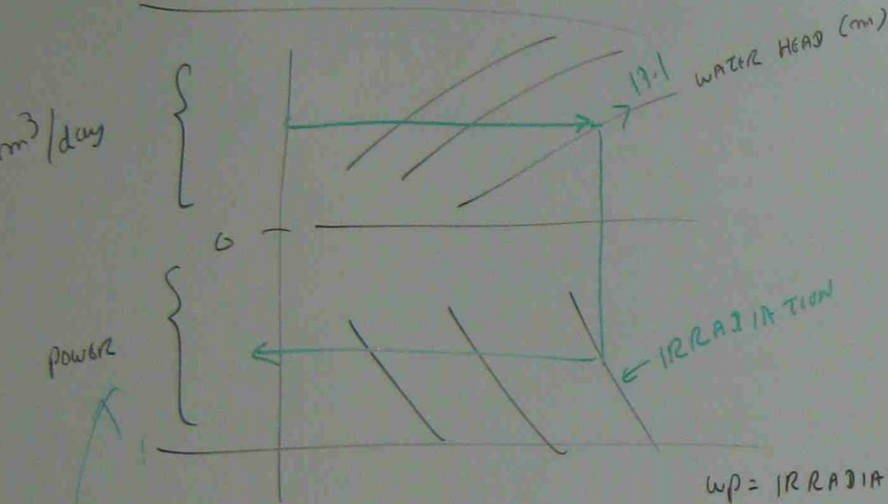
TOTAL HEAD

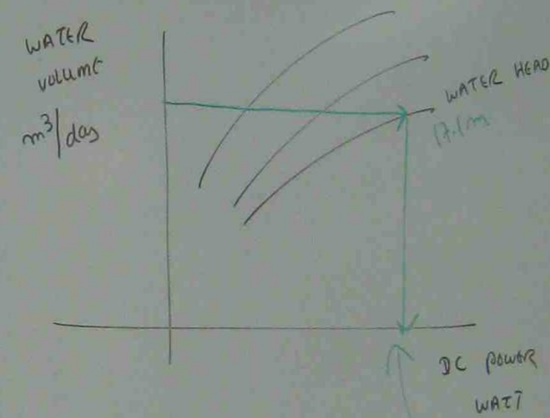
(d) $P_{SHAFT} = \dfrac{P_{IN}}{\text{shaft efficiency}} = \dfrac{915}{0.95} = 963\,W$

(e) INPUT ELECTRICAL POWER $= \dfrac{963\,W}{0.786}$

$\approx 1225\,W$

MANUFACTURER'S SYSTEM CHART





SIZE OF DC MOTOR
SIZE OF WATER PUMP

WP = IRRADIATION ON TILTED SURFACE

kWh/m^2

CAN DETERMINE THE SIZE OF BATTERY

$20\,m^3/day \longrightarrow$ 35 m HEAD $\longrightarrow 5\,kWh/m^2 \longrightarrow$ 1300 W

WATER — POWER — POWER OUTPUT

OVER ALL EFFICIENCY

$$\eta_{\text{OVER ALL}} = \eta_{\text{pump}} \times \eta_{\text{motor}} \times \eta_{\text{MPPT}} \times \eta_{\text{TRANS}} \times \eta_{\text{HYD}} \times \eta_{\text{ARRAY}}$$

$\eta_{\text{OVER ALL}}$ = OVER ALL EFFICIENCY

η_{pump} = pump EFFICIENCY

η_{motor} = motor EFFICIENCY

η_{MPPT} = MAXIMUM POWER POINT TRACKER EFFICIENCY

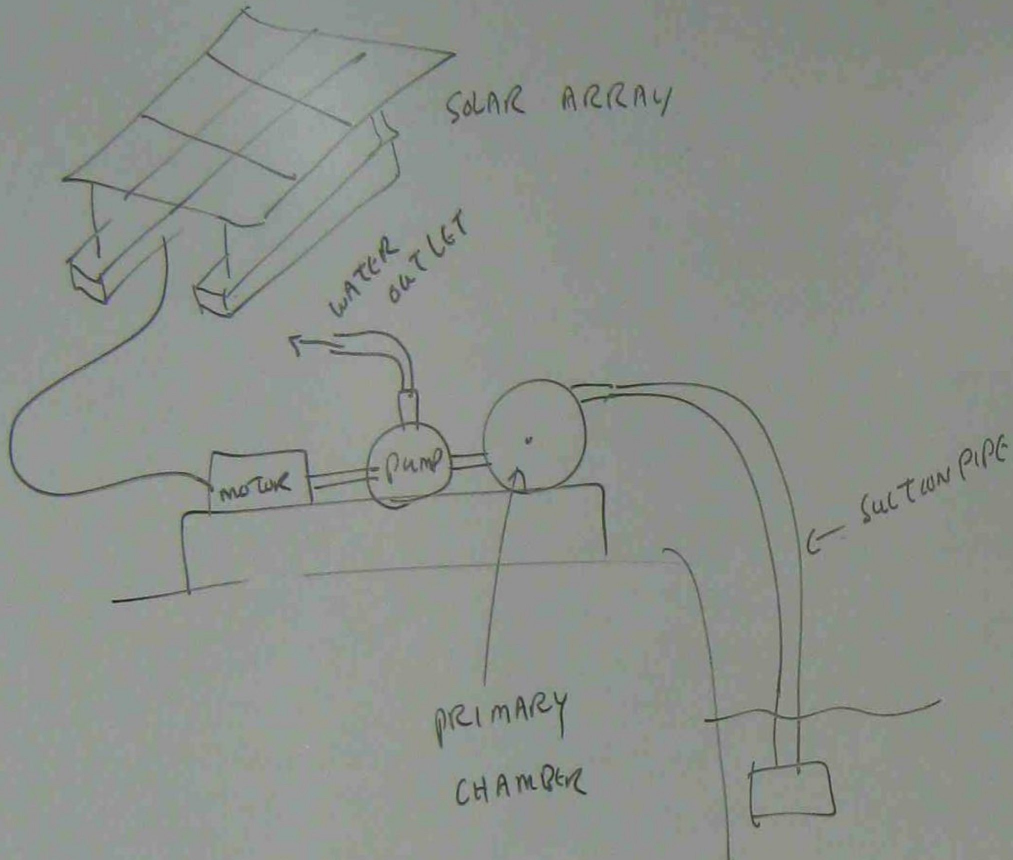
η_{TRANS} = MECHANICAL TRANSMISSION EFFICIENCY

η_{HYD} = HYDRAULIC EFFICIENCY

TOR
R pump

COMPONENT		EFFICIENCY
PUMP	PISTON	65.7
	DIAPHRAGM	73.8
	SINGLE STAGE CENTRIFUGAL	45.55
	MULTI STAGE CENTRIFUGAL	66.65
	HELICAL ROTOR	70.75
MOTOR	1φ AC	45.5
	3φ AC	50.6
	L.V DC	60.7
	H.V DC	89.43

COMPONENT	EFFICIENCY
POWER CONDITIONER	
INVERTER	90
MPPT	95.08
MECHANICAL TRANSMISSION	
VEE BELT	80.4
TOOTH HEAD BELT	95
ELECTRICAL	
CONNECTION CABLE	95
HYDRAULIC	90
PV ARRAY	10



SURFACE MOUNTER PUMP

$$\text{MAXIMUM FLOW RATE} = \frac{\text{DAILY FLOW (LITRE)}}{\text{PEAK SUN HOUR}}$$

PIPE SIZE → VELOCITY | FLOW RATE

HEAD

FLOW RATE → HEAD