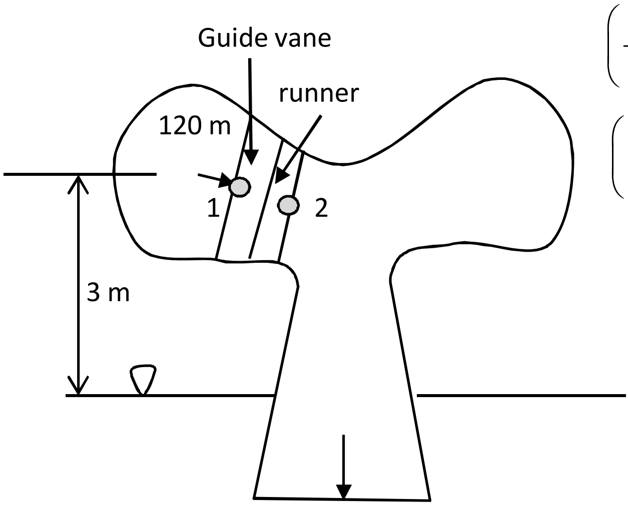
In a vertical shaft inward flow reaction turbine the sum of the pressure and kinetic heads at entrance to the spiral casing is 120 m and the vertical distance between this section and the tail race level is 3m. The peripheral velocity of the runner at entry is 30 m/s, the radial component of the velocity of water is constant at 10 m/s and the discharge from the runner is without whirl. The hydraulic losses are: (i) between turbine entrance and discharge from guide vanes, 4.5 m (ii) in the runner, 8 m (iii) in the draft tube, 0.8 m (iv) kinetic energy rejected to the tail race, 0.5 m. Determine: (a) the guide vane angle and the runner blade angle at the inlet, and (b) the pressure heads at entry and exit from the runner.

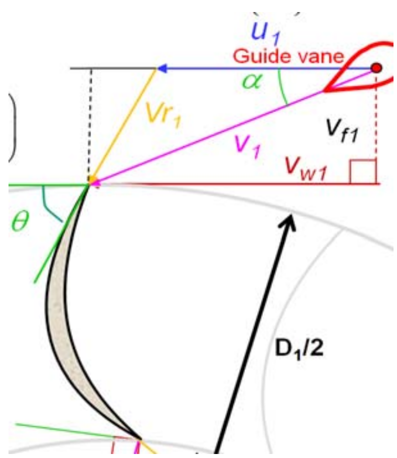
KH+PH at casing=	120	m	
casing and tailrace distance=	3	m	
u =	**30**	m/s	
vf1 =	10	m/s	without whirl
Losses			
between turbine entrance and discharge from guide vane =	4.5	m	
runner	8	m	
draft tube	0.8	m	
KE rejected at tail race	0.5	m	

α1, β1, p1/γ, p2/γ at runner = ?



$$\left(\frac{p^*}{\gamma}+\frac{v^{*2}}{2g}\right)+z^* = 120+3 = \left(\frac{p_1}{\gamma}+\frac{v_1^{\,2}}{2g}\right)+z_1+4.5$$

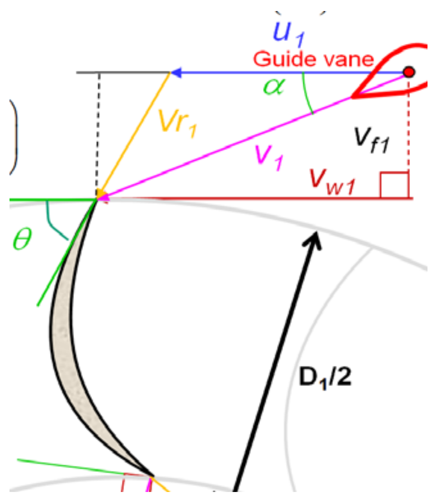
$$\left(\frac{p^*}{\gamma}+\frac{v^{*2}}{2g}\right)+z^* = 120+3 = \left(\frac{p_2}{\gamma}+\frac{v_2^{\,2}}{2g}\right)+z_2+4.5+8$$



vf1 = vf2 = V2=	10.00	m/s	without whirl
head utilised by runner= (120+3-4.5-8-0.8-0.5)=	109.20	m	
V_{w1} = (Head utilised by runner=$V_{w1}u_1/g$)	35.71	m/s	
tan (α)= (V_{f1}/V_{w1})	0.28		
guide vane angle at inlet α=	15.65	°	
blade angle at inlet θ=(tan θ=$v_{f1}/(v_{w1}-u_1)$)	60.29	°	
V_1= ($v_{f1}=V_1 \sin \alpha$)	37.1	m/s	
p1/γ= (120+3=v12/2g+p1/ γ+z1+4.5)	45.4	m of water	
p2/γ= (120+3=v22/2g+p2/ γ+z2+H+4.5+8)	-6.8	m of water	

An inward flow reaction turbine works under a head of 30 m and discharge of 10 cumec. The speed of the runner is 300 r.p.m. At the inlet tip of the runner vane the peripheral velocity of wheel is 0.9√(2gh) and the radial velocity of flow is 0.3√(2gh) , where is the head on the turbine. If the overall efficiency and hydraulic efficiency of the turbine are 80% and 90% respectively, determine (i) power developed in kW (ii) diameter and width of the runner at inlet and (iii) guide blade angle at inlet (iv) Inlet angle at runner vane β1. Assume blade thickness coefficient as 0.95.

head available H =	30	m
Q=	10	m^3/s
N=	300	r.p.m.
α2 =	90	°
ηo =	0.8	
ηh =	0.9	
Kf1= in formula ($v_{f1}=k_{f1}\sqrt{2gh}$)	0.3	
Ku1= in formula ($u_1=k_{u1}\sqrt{2gh}$)	0.9	
$K_{blade\ thickness}$	**0.95**	
Power developed= (Po= ηo γQH)	**2354.4**	kW
u1=	21.8	m/s
Vf1=	7.28	m/s
D1= (u1=πD1N/60)	**1.39**	m
b1= (Q=πD1b1vf1)	**0.331**	m
V_{w1}= ($\eta h = v_{w1} u_1/gH$)	12.13	m/s
tan (α) = (v_{f1}/v_{w1})	0.60	
guide blade angle at inlet α1 =	**30.78**	°
tan (β) = (tan $\beta = v_{f1}/(v_{w1}-u_1)$)	-0.75	
Inlet angle at runner vane β=	143.12	°



An inward flow reaction turbine with a supply of 550 lit/sec under a head of 15 m develops 74.6 kW at 400 rpm. The inner and the outer diameter of the runner are 50 cm and 75 cm respectively. The velocity of water at exit is 3 m/s assuming that the discharge is radial and that the width of the wheel is constant, find the actual and the theoretical hydraulic efficiencies of the turbine and the inlet angles of the guide and wheel vanes.

Q =	550	lit/s	0.55	m^3/sec
D1=	75	cm	0.75	m
H=	15	m		
D2=	50	cm	0.5	m
Pt= (shaft power)	100	HP	74.6	kW
vf2=v2	2.5	m/s	radial	
N=	400	rpm		
α2=	90	°	radial exit	
B1=B2				

Calculation:

u1= πD1N/60 15.71 m/s

work done by turbine per kg of water = $(v_{w1}*u_1)/g$ = head utilised by the turbine = $H-v_2^2/2g$ (assuming no loss at outlet), $v_{w2}=0$

v_{w1}=	9.17	m/s	
work done by turbine at runner=	79.21	kw	using $(\rho Q*(v_{w1}u_1))$
Available water power	80.93	kw	using γQH
overall efficiency ηo=	92.2	%	using Pt/γQH
hydraulic efficiency ηh=	97.9	%	using $(\rho Q*(v_{w1}u_1))/\gamma QH$ or $(v_{w1}u_1)/g$
$Q=\pi D1B1v_{f1}=\pi D1B1v_{f2}$	or vf1=vf2 *D2/D1		* neglect blade thickness
vf1=	1.667	m/s	
tan (β)= $v_{f1}/(v_{w1}-u_1)$	0.255		
β1	14.3	°	
v1=	9.3	m/s	
cos(α)= v_{w1}/v_1	0.98		
α=	10.3	°	