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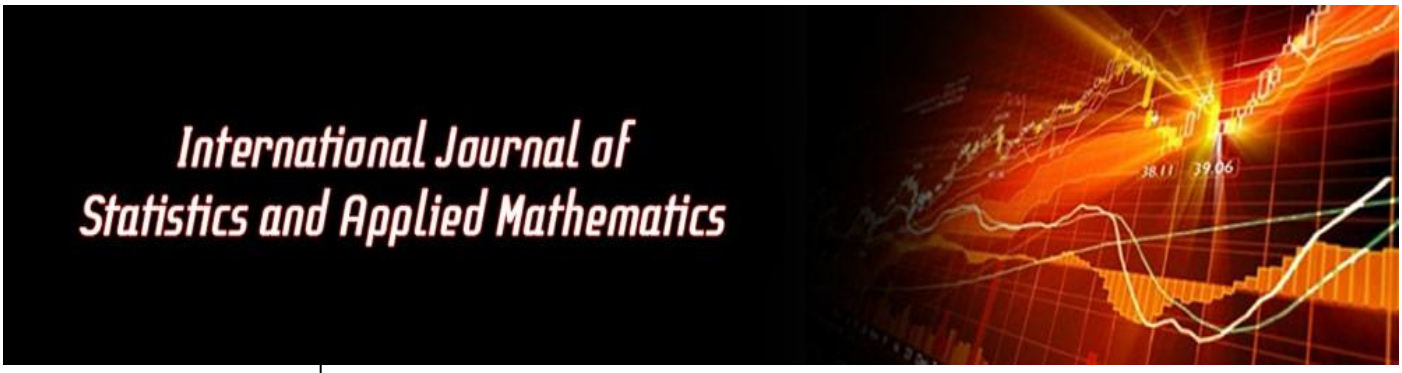

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Initial step for developing software for two phase blood flow power law model in human renal artery for dengue disease with help of python coding

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Abstract
In this paper, software for two phase blood flow using power model have been tried to develop for plotting the graph between hematocrit and blood pressure drop in medical point of view. This coding default values of different parameters have been put in the python program. Blood has been taken in two phase's first plasma and another Cell phase. since blood shows the non-Newtonian behaviour in small arteries, power law model is used for the modelling. Power index has been calculated by newton Raphson method python program. finally we found the table and graph for Blood Pressure Drop and HCT.

Keywords: Power law model, plasma, cells, hematocrit, non- Newtonian

Introduction
In large channels, such as the enormous arteries and veins and the heart's ventricles and atria, the blood often behaves like a Newtonian fluid. One explanation is that because blood in such large lumens and cavities is usually subjected to extremely high shear rates, non-Newtonian effects, which are primarily formed at low shear rates, gradually fade away [1]. At this enormous size, blood also appears as a uniform continuum media, with the influence of blood cell aggregation diminishing [2].
Non-Newtonian effects are generally more pronounced in small flow channels, such as renal artery, than in large ducts, such as arteries. The breakdown of the continuity assumption at small scales, which is especially true for intricate distributed systems like blood, is one of the reasons behind this. In these kinds of tubes, the continuum approximation reaches a limit when blood cells aggregate and interact with the vessel wall. This starts the non-Newtonian rheological flow modes, which include the induction of elastic effects connected to the structural and elastic properties of red blood cells. Moreover, low shear rates, which are the prevalent flow regimes in the small vessels, make the non-Newtonian effects of blood more apparent [3]. Hence, while modelling, simulating, and analysing the flow of blood in small vessels, non-Newtonian rheological effects should be taken into account. The Power Law Model is one of several rheological models used to describe non-Newtonian fluid behavior.

Dengue and renal artery
Tropical and subtropical regions of the world are home to dengue fever, also known as DENG-gey fever, which is spread by mosquitoes. Flu-like symptoms and a high temperature are signs of mild dengue fever. Serious bleeding, a sharp drop in blood pressure (shock), and even death are possible outcomes of the severe type of dengue fever, commonly known as dengue hemorrhagic fever. Every year, millions of people throughout the world contract dengue. Southeast Asia, the western Pacific islands, Latin America, and Africa are the regions with the highest rates of dengue fever. However, the illness has been moving to other regions, with isolated outbreaks occurring in southern U.S. states and Europe. Vaccines against dengue disease are being developed.
For now, in areas where dengue fever is common, the best ways to prevent infection are to avoid being bitten by mosquitoes and to take steps to reduce the mosquito population.

Symptoms

Many people experience no signs or symptoms of a dengue infection. When symptoms do occur, they may be mistaken for other illnesses — such as the flu — and usually begin four to 10 days after you are bitten by an infected mosquito.

Dengue fever causes a high fever — 104 F (40 C) — and any of the following signs and symptoms:

- Headache
- Muscle, bone or joint pain
- Nausea
- Vomiting
- Pain behind the eyes
- Swollen glands
- Rash

Most folks get better in about a week. Sometimes the symptoms get worse and can prove fatal. This is known as dengue shock syndrome, dengue hemorrhagic fever, or severe dengue.

When your blood vessels are damaged and start to leak, you get severe dengue. Additionally, your blood's concentration of platelets, which are cells that form clots, decreases. Shock, internal hemorrhage, organ failure, and even death may result from this.

Severe dengue fever is a potentially fatal condition that can manifest warning symptoms rapidly. Usually during the first day or two after your fever subsides, the warning symptoms might include:

- Severe stomach pain
- Persistent vomiting
- Bleeding from your gums or nose
- Blood in your urine, stools or vomit
- Bleeding under the skin, which might look like bruising
- Difficult or rapid breathing
- Fatigue
- Irritability or restlessness

With an estimated 400 million infections each year, of which 100 million (25%) result in clinical illness [4], dengue is the most common arthropod-borne viral disease in the world. A dengue viral infection (DVI) can manifest with a variety of symptoms, such as various end-organ damage, nonspecific fever, and potentially fatal symptoms. Relatively little research has been done on the epidemiology of renal involvement in dengue fever and its variants. It is necessary to comprehend the processes underlying acute kidney damage (AKI).

Research indicates that the prevalence of renal symptoms in dengue varies greatly (0.9% to 69.4%), and AKI is a rare dengue complication with a frequency of around 014% [5, 6]. In dengue, AKI has been linked to higher rates of morbidity and death [7]. The main source of evidence for dengue's correlation with AKI is historical data from different geographical areas [8].

The mean peak systolic velocity (PSV) was highest on the left side in males measuring 65.75 ± 28.41cm/sec and 60.7 ± 24.20cm/sec on the right [9].

The main renal arteries are approximately 4 to 6 cm long with a 5 to 6 mm diameter. The right renal artery, which is longer than the left, arises from the anterolateral aorta and runs in an inferior course posterior to the inferior vena cava (IVC) to reach the right kidney [10, 11].

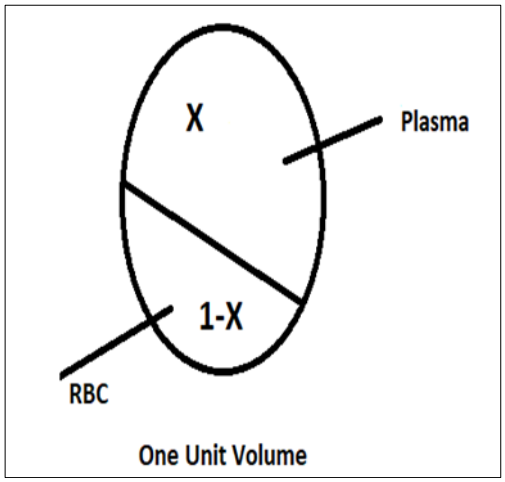
Real Model

When blood flows via a larger artery, Newtonian blood behaviour is reasonable to anticipate. It is not acceptable if the blood vessel is small (radius less than 1 mm). From the standpoint of biofluid mechanics, blood would not be expected to obey Newton's incredibly simple, one parameter, linearized law of viscosity. The non-Newtonian characteristics of blood can only be accurately represented by higher order constitutive equations, such as the power-law paradigm Enderle.

Parametrization

The blood's velocity$v^k = v^k(X^i, t) k = 1,2,3$ and any two thermodynamic quantities related to it, such as pressure, $P = P(X^i, t)$ and density,$\rho = \rho(X^i, t)$, were distributed according to functions that affected the mathematical description of the state of a moving blood. All thermodynamic quantities, together with the equation of state, are determined by the values of any two of them, as is often known. Thus, we may fully ascertain the condition of flowing blood if we have five variables: the densityρ, the pressure$P$, and the three components of velocity v^k.

The coordinates$X^i, i = 1,2,3$, and the time t are functions of all these values. It stressed that the blood's velocity at a given position X^i in space and at a given time t was represented by the expression $v^k(X^i, t)$



Let one unit volume of whole blood and
$X =$ Volume fraction of plasma
$Y = 1 - X =$ Volume fraction of RBC the mass ratio of RBC to plasma is m

$$m = \frac{Y\rho_C}{X\rho_P}$$

Where ρ_C, ρ_P, ρ_W are the densities of RBC,plasma, WBC.
We define density of blood mixture ρ_m as follows

$$\frac{1+m}{\rho_m} = \frac{m}{\rho_c} + \frac{1}{\rho_P}$$

And viscosity of blood mixture η_m as follows

$$\eta_m = Y\eta_c + X\eta_P$$

Boundary conditions

1. The velocity of blood flow on the axis of blood vessels at r = 0 will be maximum and finite, say $v_0 =$ maximum velocity.
2. The velocity of blood flow on the wall of blood vessels at $r = R$, where, R is the radius of blood vessels, will be zero. This condition is well known as no slip condition.

Equation of Continuity

Continuity equation for three phases

$$\frac{\partial((1-X)\rho_c)}{\partial t} + ((1-X)\rho_c v^i)_{,i} = 0 \quad [1]$$

$$\frac{\partial(X\rho_P)}{\partial t} + (X\rho_P v^i)_{,i} = 0 \quad [2]$$

Where, v^i is the common velocity of two phase blood cells and plasma. Again $(X\rho_c v^i)_{,i}$ is co-variant derivative of $(X\rho_c v^i)$ with respect toX^i.

Equation of motion for blood flow with the three phases.
Using the principle of force conservation (or momentum conservation) in hepatic arteries and assuming that the consistency coefficient (or viscosity coefficient) of RBC cells is η_c.

$$(1-X)\rho_c \frac{\partial v^i}{\partial t} + \left((1-X)\rho_c v^i\right) v^i_{,j} - (1-X)P_{,j}g^{ij} + (1-X)\eta_c\left(g^{jk}v^i{}_{,k}\right)_{,j}$$

Similarly, taking the viscosity coefficient of plasma to be the equation of motion for plasma will be as follows-

$$X\rho_P \frac{\partial v^i}{\partial t} + (X\rho_P v^i)v^i_{,j} - XP_{,j}g^{ij} + X\eta_P\left(g^{jk}v^i{}_{,k}\right)_{,j}$$

then equation of motion for blood flow with the all Two phases will be as follows-

$$\rho_m \frac{\partial v^i}{\partial t} + (\rho_m v^j)v^i{}_{,j} = -P_{,j}g^{ij} + \eta_m\left(g^{jk}v^i{}_{,k}\right)_{,j} \quad [3]$$

Whenever percentage of blood is reduces the blood has been supposed Newtonian but in case of increasing the hematocrit, the effective viscosity of blood flowing through arteries remote from the heart depends on the strain rate.

For this reason, the blood will flow as non Newtonian fluid. When strain rate is in between 5 to 200 per second, the power law

$\tau' = \eta_m e^n$

Where $0.68 \leq n \leq 0.80$ describes the flow of blood very well. The constitutive equation of blood is as follow

Blood's constitutive equation is as follows.

$$\tau^{ij} = -pg^{ij} + \eta_m (e^{ij})^n = -pg^{ij} + \tau'^{ij} \quad [4]$$

Where τ^{ij} is stress tensor and τ'^{ij} is shearing stress tensor.

Mathematical formulation

The equation of continuity for power law flow will be as follows:

$$\frac{1}{\sqrt{g}}(\sqrt{g}v^i)_{,i} = 0 \quad [5]$$

Again the equation in tensorial form is as follows:

$$\rho_m \frac{\partial v^i}{\partial t} + \rho_m v^j v^i{}_{,j} = \tau^{ij}{}_{,j} \quad [6]$$

Since the blood vessels are cylindrical, the above governing equation have to transformed into cylindrical co-ordinates.

Let $x^1 = r, x^2 = \theta, x^3 = z$

Matrix of corresponding metric tensor in cylindrical form is as follow:

$$[g_{ij}] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & r^2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

So Matrix of conjugate metric tensor is

$$[g^{ij}] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{r^2} & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Whereas Christoffel's symbols of 2nd kind are as follows:

$\begin{Bmatrix} 1 \\ 2 \quad 2 \end{Bmatrix} = -r, \begin{Bmatrix} 2 \\ 2 \quad 1 \end{Bmatrix} = \begin{Bmatrix} 2 \\ 1 \quad 2 \end{Bmatrix} = \frac{1}{r}$ Except of these all are zero.

contravarient and physical components of velocity of blood flow will be related as

$\sqrt{g_{11}}v^1 = v_r \Rightarrow v_r = v^1$

$\sqrt{g_{22}}v^2 = v_\theta \Rightarrow v_\theta = rv^2,$

$\sqrt{g_{22}}v^3 = v_z \Rightarrow v_z = v^3$

Further the physical component of $-p_{,j}\, g^{ij}$ are $-\sqrt{g_{ii}}p_{,j}\, g^{ij}$

The matrix of physical component of shearing stress – tensor

$$\tau'^{ij} = \eta_m (e^{ij})^n = \eta_m (g^{ik} v^i_{,k} + g^{jk} v^j_{,k})^n \quad [7]$$

will be as follows:

$$\begin{bmatrix} 0 & 0 & \eta_m(dv/dz)^n \\ 0 & 0 & 0 \\ \eta_m(dv/dr)^n & 0 & 0 \end{bmatrix}$$

The covariant derivative of $\tau^{,ij}$ is

$$\tau^{,ij}_{,j} = \frac{1}{\sqrt{g}}\frac{\partial}{\partial x^j}\left(\sqrt{g}\tau^{,ij}\right) + \left\{ {j \atop } {i \atop k} \right\}\tau^{,kj} \quad [8]$$

Keeping in view the above facts the governing tensorial equation can be transformed into cylindrical form which are as follows:

The Equation of continuity

$$\frac{\partial v}{\partial z} = 0$$

The Equation of motion

r-Component

$$-\frac{\partial p}{\partial r} = 0$$

θ-Component

$$0 = 0$$

Z-Component

$$0 = -\frac{\partial p}{\partial z} + \frac{\eta_m}{r}\frac{\partial}{\partial r}\left(r\left(\frac{dv}{dr}\right)^n\right)$$

These are ther, θ, z components respectively
Further the fact has been considered that axial flow in artery is symmetric, so that $v_\theta = 0\ and\ v_r, v_z\ and\ p$ do not depend upon θ. Also the blood flows steadily, i.e.

$$\frac{\partial p}{\partial t} = \frac{\partial v_r}{\partial t} = \frac{\partial v_\theta}{\partial t} = \frac{\partial v_z}{\partial t} = 0$$

On integrating equation, we get $v_z = v(r)$ because v does not depend upon θ
The integration of equation of motion, we get $p = p(z)$ since p does not depend upon θ

Now, with the help of equation, the equation of motion converts in the following form:

$$0 = -\frac{dp}{dz} + \frac{\eta_m}{r}\frac{d}{dr}\left(r\left(\frac{dv}{dr}\right)^n\right) \quad [9]$$

The pressure gradient $-(dp/dz) = P$ of blood flow in the arteries remote from liver can be supposed to be constant and hence the equation takes the following form:

$$\frac{d}{dr}\left(r\left(\frac{dv}{dr}\right)^n\right) = -\frac{Pr}{\eta_m}$$

On integrating equation (9), we get

$$r\left(\frac{dv}{dr}\right)^n = -\frac{Pr^2}{2\eta_m} + A \quad [10]$$

We know that the velocity of blood flow on the axis of the cylindrical arteries is maximum and constant. So that the apply the boundary condition at r=0, v = V_0(contant), on equation (10) to get the arbitrary constant A = 0. Hence the equation (11) takes the following form:

$$r\left(\frac{dv}{dr}\right)^n = -\frac{Pr^2}{2\eta_m}$$

$$-\frac{dv}{dr} = \left(\frac{Pr}{2\eta_m}\right)^{1/n} \quad [11]$$

Integrating equation (11) once again, we get

$$v = -\left(\frac{P}{2\eta_m}\right)^{1/n} \frac{r^{\frac{1}{n}+1}}{(n+1)/n} + B \quad [12]$$

To determine the arbitrary constant B, we apply the no –slip condition in the inner wall of the arteries: at $r = R, V = 0$, where $R =$ radius of vessel, on equation (12) so as to get

$$B = \left(\frac{P}{2\eta_m}\right)^{1/n} \frac{nR^{\frac{1}{n}+1}}{n+1}$$

Hence the equation takes the following form:

$$v = \left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} \frac{n}{n+1}\left[R^{\frac{1}{n}+1} - r^{\frac{1}{n}+1}\right] \quad [13]$$

Which determines the velocity of blood flow in the arteries remote from the liver where P is gradient of blood pressure and η_m is the viscosity of blood mixture.

Shear stress

$$\tau = \left(\frac{Q(1+3n)}{\pi n}\right)^n \frac{r\eta_m}{R^{3n+1}}$$

Strain rate $\frac{dv}{dr} = \left(\frac{\Delta Pr}{2\Delta z\, \eta_m}\right)^{1/n}$

The total flow- flux of blood through the transverse section of the arteries is

$$Q = \int_0^R v.2\pi r\, dr = \int_0^R \left(\frac{P}{2\eta_m}\right)^{1/n} . \frac{1}{n+1}\left(R^{\frac{1}{n}+1} - r^{\frac{1}{n}+1}\right) 2\pi r\, dr$$

$$= \left(\frac{P}{2\eta_m}\right)^{1/n} . \frac{2\pi n}{n+1}\left(\frac{R^{1/n+1}.r^2}{2} - \frac{n.r^{\frac{1}{n}+3}}{3n+1}\right)_0^R$$

$$= \left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} . \frac{2\pi n}{n+1} . \frac{(n+1)R^{1/n+3}}{2(3n+1)}$$

$$Q = \left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} . \frac{\pi n R^{\frac{1}{n}+3}}{(3n+1)}, where\ P = -\frac{dp}{dz}$$

$$Q = \left[\frac{P_i - P_f}{2\eta_m(z_i - z_f)}\right]^{\frac{1}{n}} . \frac{\pi n R^{\frac{1}{n}+3}}{(3n+1)} \quad [14]$$

Observations

According to Glenn Elert (2010)

η_m = Viscosity of mixture = 0.0045 pascal sec

According to Gustafson, Daniel R. (1980)

η_p = Viscosity of plasma =0.0015 pascal sec

η_c= 0.0075 pascal sec [9]

Length of renal artery$(z_i - z_f)$ = 0.05 meter

Table 1: Data of dengue patient

S.N	DATE	B.P(mmHg)	Hb	Hct
1	11/11/2024	110.02/73.08	12.9	38.7
2	13/11/2024	109.10/72.30	11.3	33.9
3	14/11/2024	110.90/71.80	10.7	32.1
4	15/11/2024	112.90/74.10	11.7	35.1
5	16/11/2024	114.90/76.00	12.1	36.3

Average Systolic Pressure =111.04 mm Hg
Average Diastolic Pressure = 74.13 mm Hg
Pressure drop =2460.60 pascal

Coding for calculation

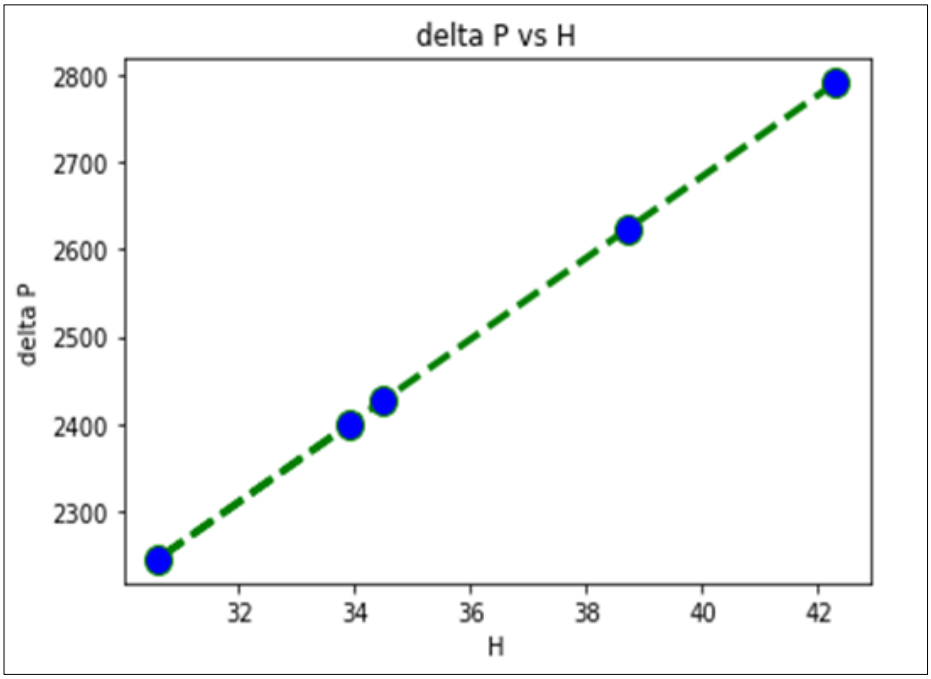
```
Import numpy as np from math import log10 as log import matplotlib. pyplot as plt

def equation_etaM_vs_h(h, etaM_init, etaP_init):
etaC_init = 100*(etaM_init-etaP_init*(1-(h/100)))/h

slope_etaM = (etaC_init-etaP_init)/100
intercept_etaM = etaP_init
return etaC_init, slope_etaM, intercept_etaM

def find_n(n, delta_p, etaM, delta_z, R, Q):
###
fn = (log(delta_p/(2*etaM*delta_z)))/n + log(3.14) + log(n) + 3*log(R) + (log(R))/n - log(1 + 3*n) - log(Q)
fn_prime = -(log(delta_p/(2*etaM*delta_z)))/(n**2) + (1/n) - log(R)/(n**2) - 3/(1+3*n)
###
delta = fn/fn_prime
n_new = n - delta
return n_new, delta

def get_optimized_n_value(n_init, delta_p, etaM, delta_z, R, Q, iteration_count, eps):
# print(f"\n\n***** working on {equation} ******")
success = True
for i in range(iteration_count):
try:
n_new, delta = find_n(n=n_init, delta_p=delta_p, etaM=etaM, delta_z=delta_z, R=R, Q=Q)
# if equation=="eq1":
# x_new, delta = get_newton_raphson_eq1(x_init)
# elif equation=="eq2":
# x_new, delta = get_newton_raphson_eq2(x_init)
# else:
# x_new, delta = get_newton_raphson_eq3(x_init)
# print(f"n_new: {n_new}")
temp = n_new
if abs(delta)<=eps:
iteration_count = i+1

break
n_init = n_new
except:
success=False
n_new = n_init
temp = n_new
iteration_count = i
print(f"wrong initial guess: getting n_new = {temp} at {iteration_count} iteration")
break
abs_per_error = abs((n_new-n_init)/n_new)*100
return n_new, iteration_count, abs_per_error, success

def equation_deltaP_vs_h(n, Q, R, delta_z, slope_etaM, intercept_etaM):
pi = 3.14
factor = (((3*n + 1)*Q/(pi*n*(R**3)))**n)*(2*delta_z/R)
# print(f"factor: {factor}")
slope_delta_p = factor*slope_etaM
```

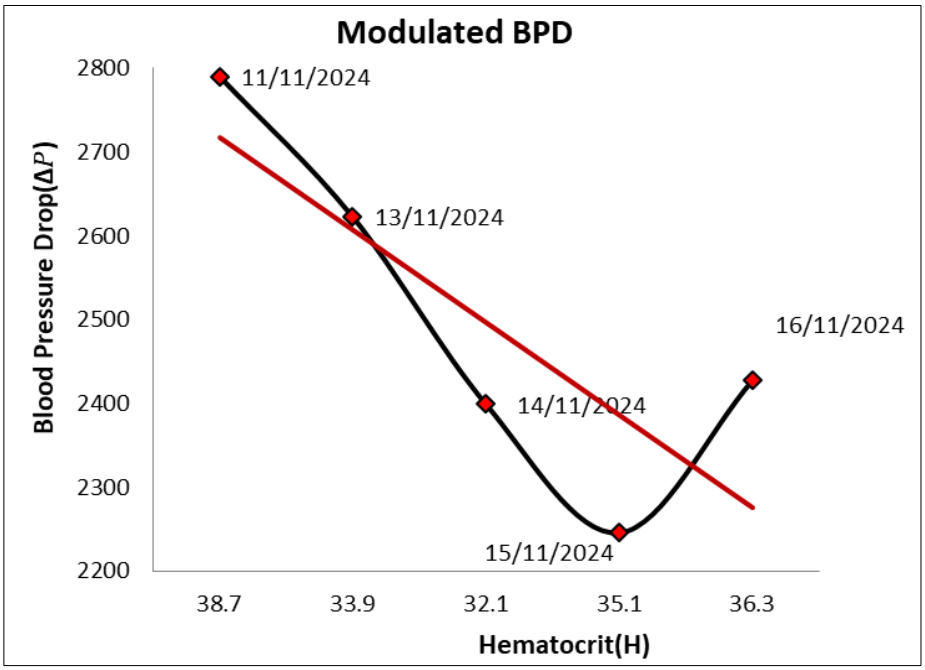
```
intercept_delta_p = factor*intercept_etaM
return slope_delta_p, intercept_delta_p

def get_final_pressure_drop(h,
etaM_init,
etaP_init,
n_init,
delta_p,
delta_z,
R,
Q,
iteration_count,
eps):
etaC_init, slope_etaM, intercept_etaM = equation_etaM_vs_h(h=h, etaM_init=etaM_init, etaP_init=etaP_init)

n_new, iteration_count, abs_per_error, success = get_optimized_n_value(n_init=n_init, delta_p=delta_p, etaM=etaM_init,
delta_z = delta_z, R=R, Q=Q, iteration_count=iteration_count, eps=eps)

# print(f"n: {n_new}\niteration_count: {iteration_count}\nabs error: {abs_per_error}")
if success:
slope_delta_p, intercept_delta_p = equation_deltaP_vs_h(n=n_new, Q=Q, R=R, delta_z=delta_z, slope_etaM=slope_etaM,
intercept_etaM=intercept_etaM)
else:
print("n optimization failed!!")
slope_delta_p, intercept_delta_p = 0, 0

return etaC_init, slope_etaM, intercept_etaM, n_new, slope_delta_p, intercept_delta_p

def calculate_p(h_dict, slope_delta_p, intercept_delta_p):
p_list = []
h_list = []
date_list = []
for date_ in h_dict:
h = h_dict[date_]
p = slope_delta_p*h + intercept_delta_p
h_list.append(h)
p_list.append(p)
date_list.append(date_)
return p_list, h_list, date_list

def draw_graph(p_list, h_list, date_list):
# plotting the points
plt.plot(h_list, p_list, color='green', linestyle='dashed', linewidth = 3,
marker='o', markerfacecolor='blue', markersize=12)

# naming the x axis
plt.xlabel('H')
# naming the y axis
plt.ylabel('delta P')

# giving a title to my graph
plt.title('delta P vs H')

# function to show the plot
return plt.show()

if __name__=="__main__":
# Add all parameters here
h=35.22 # initial h
etaM_init=0.0045
etaP_init=0.0015

n_init = 1.2 # n initial guess
delta_p = 2460.60 # 14804.96 - 12344.35
delta_z = 0.05
```

```
R = 0.00275
Q = 0.000011
iteration_count=100
eps = 0.00000000000001
############################
# Add datewise h value in below format only
date_h_dict = {
"11-11-2024": 42.3,
"13-11-2024": 38.7,
"14-11-2024": 33.9,
"15-11-2024": 30.6,
"16-11-2024": 34.5,
}

############################
# etaC_init, slope_etaM, intercept_etaM = equation_etaM_vs_h(h=h, etaM_init=etaM_init, etaP_init=etaP_init)

# n_new, iteration_count, abs_per_error, success = get_optimized_n_value(n_init=n_init, delta_p=delta_p, etaM=etaM_init,
# delta_z = delta_z, R=R, Q=Q, iteration_count=iteration_count, eps=eps)

# # n_new = 0.7189522
# # slope_etaM = 0.00004756
# # intercept_etaM = 0.0015
# slope_delta_p, intercept_delta_p = equation_deltaP_vs_h(n=n_new, Q=Q, R=R, delta_z=delta_z, slope_etaM=slope_etaM,
# intercept_etaM=intercept_etaM)

# print(etaC_init, slope_etaM, intercept_etaM)
# print(n_new, iteration_count, abs_per_error, success)
# print(slope_delta_p, intercept_delta_p)
############################
etaC_init, slope_etaM, intercept_etaM, n_new, slope_delta_p, intercept_delta_p = get_final_pressure_drop(h=h,
etaM_init=etaM_init,
etaP_init=etaP_init,
n_init=n_init,
delta_p=delta_p,
delta_z=delta_z,
R=R,
Q=Q,
iteration_count=iteration_count,
eps=eps)

# print(etaC_init, slope_etaM, intercept_etaM)

print(n_new)
# print(slope_delta_p, intercept_delta_p)

print(f"etaC_init: {etaC_init}\nslope of delta p and h: {slope_delta_p}\nintercept of delta p and h: {intercept_delta_p}")

p_list, h_list, date_list = calculate_p(date_h_dict, slope_delta_p, intercept_delta_p)
print(f"p_list: {p_list}\nh_list: {h_list}")
draw_graph(p_list=p_list, h_list=h_list, date_list=date_list)
output of the coding
1.496702037859311
etaC_init: 0.010017887563884156
slope of delta p and h: 46.57580919931843
intercept of delta p and h: 820.1999999999975
p_list: [2790.356729131167, 2622.683816013621, 2399.1199318568924, 2245.4197614991417, 2427.0654173764833]
h_list: [42.3, 38.7, 33.9, 30.6, 34.5]
```

Table 2: MBPD V/S hematocrit(H)

S. No.	Date	Hematocrit (H)	MBPD (ΔP_{modu}) in Pascal
1	11/11/2024	38.7	2790.35
2	13/11/2024	33.9	2622.68
3	14/11/2024	32.1	2399.11
4	15/11/2024	35.1	2245.41
5	16/11/2024	36.3	2427.06





Conclusion

Blood pressure drop decrease and hematocrit were shown to be linearly related $\Delta P = 46.57H + 988.091$.$\Delta P_{max} = 2790.35$ pascal and $\Delta P_{min} = 2245.41$pascal. The trend line displays a low-steep downhill trend. Thus, we can up the medication dosage in this case to help the dengue patient recover quickly. We shall gradually reduce the medicine dosage if the trend line shows an upward tendency day by day. In this article, the doctor is advised to administer the medication dosage to the dengue patient during the case.

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