PHYSOL-3 EXAMINATION SERIES

Model Exam

SUNDAY 29-05-2022 @ 7.00pm

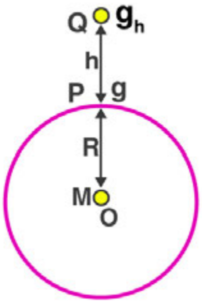
Answerkey

Answer any 4 questions from 1 to 6. Each carries 1 score

1	Strong Nuclear Force	**1**
2	2,5	**1**
3	(iii) Y	**1**
4	Pascal's law.	**1**
5	(iii) Water	**1**
6	i) Doppler effect	**1**

Answer any 8 questions from 7 to 17. Each carries 2 score

7	Surface Area of a sphere , A =4 πr^2 The error in the measurement of r i.e. $\Delta r/r$ = 2%, Therefore $\Delta A/A = 2 (\Delta r/r) = 2\times 2\% = 4\%$ Volume of a sphere, V =4/3 πr^3 The error in the measurement of r i.e. $\Delta r/r$ = 2%, Therefore $\Delta V/V = 3 (\Delta r/r) = 3\times 2\% = 6\%$	**1** **1**
8	a) Stopping distance $S=\frac{u^2}{2a}$ b) Stopping distance $S=\frac{u^2}{2a}$ If u = 2u, then $S'=\frac{(2u)^2}{2a}=\frac{4u^2}{2a}=4S$ That is Stopping distance becomes four times.	**1** **1**
9	By Newton's second law, $\vec{F}=k\frac{d\vec{P}}{dt}$ But $\vec{P}=m\vec{v}$ Therefore $\vec{F}=k\frac{d(m\vec{v})}{dt}$ $\vec{F}=km\frac{d\vec{v}}{dt}$ $\vec{F}=km\vec{a}$ But k=1 Therefore $\vec{F}=m\vec{a}$	**2**
10	Work -Energy theorem states that "Work done is equal to change in Kinetic energy". Let m--> mass of the body u--> initial velocity v--> final velocity a--> acceleration S--> displacement.	

	By equation of motion $v^2=u^2+2as$ $v^2-u^2=2as$ Therefore $as=\frac{(v^2-u^2)}{2}$ But W = F.S=mas $W=\frac{1}{2}mv^2-\frac{1}{2}mu^2=KE_f-KE_i$ That is Work done is equal to change in Kinetic energy. This is the work energy theorm.	**2**
11	Let g--> acceleration due to gravity on the surface of earth. **g_h**--> acceleration due to gravity at a height 'h'. h--> height from the surface of earth. R--> Radius of earth. M--> Mass of earth. We have $g=\frac{GM}{R^2}$ and $g_h=\frac{GM}{(R+h)^2}$  Therefore $g_h=\frac{GM}{R^2(1+\frac{h}{R})^2}=g(1+\frac{h}{R})^{-2}$ For $\frac{h}{R}$ << 1 , using binomial expression, $g_h=g[1-\frac{2h}{R}]$ Thus the acceleration due to gravity decreases with height from the surface of earth.	**2**
12	Moon has no atmosphere because the value of acceleration due to gravity g on surface of the moon is small. Therefore, the value of escape speed on the surface of the moon is small (only 2.5kms^{-1}). The molecules of the atmospheric gases on the surface of the moon have thermal speeds greater than the escape speed. That is way all the molecules of gases have escaped and there is no atmosphere on the moon.	**2**
13	Heat lost by water = heat gained by ice $m_w s_w(T_w-T)=m_{ice}s_w(T-T_{ice})+m_{ice}L$ $0.30\times 4186(50-6.7)=0.15\times 4186\times(6.7-0)+0.15\times L$ L= $3.354\times 10^5\ Jkg^{-1}$	**2**
14	a) Convection. Conduction. Radiation. b)The pendulum of the clock are made of invar. The coefficient of volume expansion of invar is low. $T=2\pi\sqrt{\frac{l}{g}}$. So even when temperature changes, there is no change in length of pendulum. So the clock keeps correct time in all seasons.	**1** **1**
15	We have given KE =PE $\frac{1}{2}m\omega^2(A^2-x^2)=\frac{1}{2}m\omega^2x^2$ $A^2=2x^2$	**2**

	$x=\frac{A}{\sqrt{2}}$ This is the distance from mean position at which KE= PE.	
16	a) Amplitude $= 0.005\,m$ b) $k=\frac{2\pi}{\lambda}=80$ $\lambda=\frac{2\pi}{80}$ $=\frac{2\times 3.14}{80}$ $=0.0785\,m$	**1** **1**
17	a) frequency, $f=\frac{420}{60}$ $= 7\,Hz$ $\therefore$ Angular speed, $\omega = 2\pi f$ $= 2\times 3.14\times 7$ $= 43.96\ rad/s$ b) Linear speed ; $v = r\omega$ $= 0.4\times 43.96$ $= 17.58\ m/s$	**1** **1**

Answer any 6 questions from 18 to 26. Each carries 3 score

18	a) Using Principle of homogeneity check dimension of each term in both equations b) 1. The method does not give any information about the dimensionless constant K. 2. It fails when a physical quantity depends on more than three physical quantities. 3. It fails when a physical quantity is the sum or difference of two or more quantities. 4. It fails to derive the equations involving trignometric, logarithmic and exponential functions.	1 2
19	a) parallelogram law of vector addition	1

b)

From right angled triangle OCD,

$$OC^2 = OD^2 + CD^2$$
$$= (OA + AD)^2 + CD^2$$
$$= OA^2 + AD^2 + 2.OA.AD + CD^2 \quad ...(1)$$

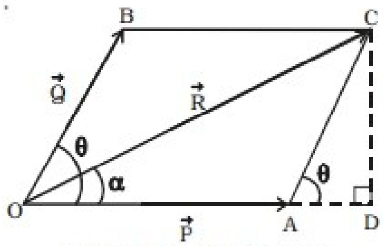


Fig 2.15 Parallelogram law of vectors

In Fig. 2.15 $\angle BOA = \theta = \angle CAD$

From right angled Δ CAD,

$$AC^2 = AD^2 + CD^2 \quad ...(2)$$

Substituting (2) in (1)

$$OC^2 = OA^2 + AC^2 + 2OA.AD \quad ...(3)$$

From ΔACD,

$$CD = AC \sin\theta \quad ...(4)$$

$$AD = AC \cos\theta \quad ...(5)$$

Substituting (5) in (3) $OC^2 = OA^2 + AC^2 + 2\, OA.AC \cos\theta$

Substituting $OC = R$, $OA = P$,

$OB = AC = Q$ in the above equation

$$R^2 = P^2 + Q^2 + 2PQ\cos\theta$$

(or) $R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$ ...(6)

Equation (6) gives the magnitude of the resultant. From Δ OCD,

$$\tan\alpha = \frac{CD}{OD} = \frac{CD}{OA + AD}$$

Substituting (4) and (5) in the above equation,

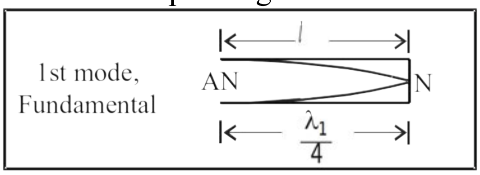
$$\tan\alpha = \frac{AC\sin\theta}{OA + AC\cos\theta} = \frac{Q\sin\theta}{P + Q\cos\theta}$$

(or) $\alpha = \tan^{-1}\left[\frac{Q\sin\theta}{P + Q\cos\theta}\right]$ ...(7)

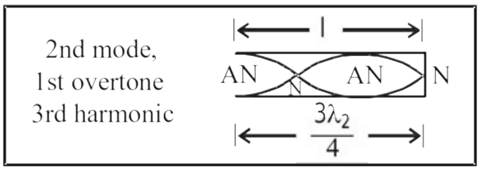
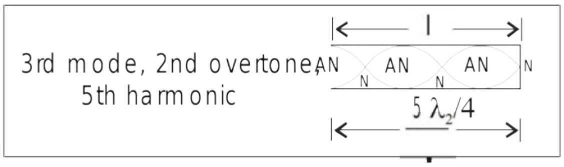
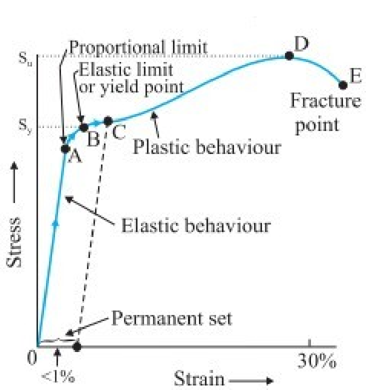
Equation (7) gives the direction of the resultant.

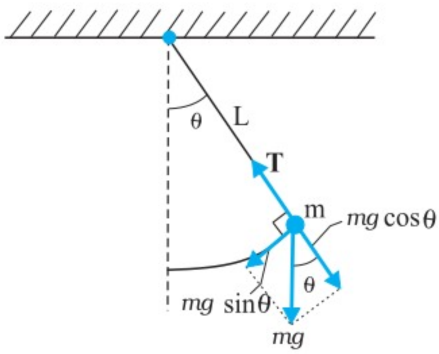
2

20 The air column in a closed pipe can vibrate in different modes. In all modes the closed end is a node and the open end is an antinode. In between there may or may not be nodes and antinodes depending on the mode of vibration.



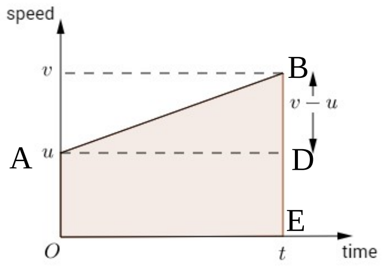
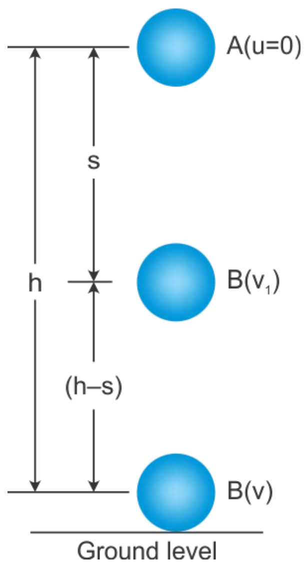
$$\frac{\lambda_1}{4} = \ell$$
$$\lambda_1 = 4\,l$$

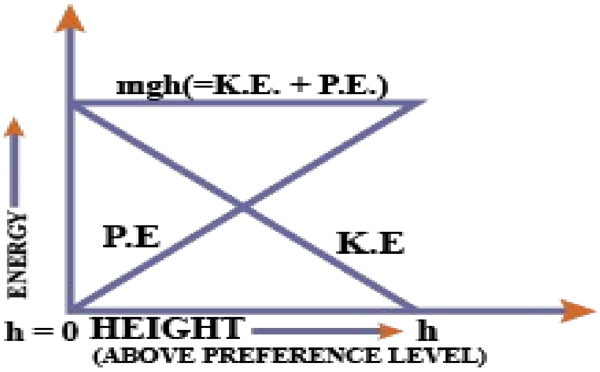
	Fundamental frequency $\nu_1 = \frac{v}{\lambda_1} = \frac{v}{4\,l}$  $\frac{3\lambda_2}{4} = l$ $\lambda_2 = \frac{4l}{3}$ Frequency of 2nd mode $\nu_2 = \frac{v}{\lambda_2}$ $= \frac{v}{\left(\frac{4l}{3}\right)} = 3\left(\frac{v}{4\,l}\right) = 3\nu_1$  $\frac{5\lambda_3}{4} = l \quad \lambda_3 = \frac{4l}{5}$ Frequency of 3rd mode $\nu_3 = \frac{v}{\lambda_3} = \frac{v}{\left(\frac{4l}{5}\right)} = 5\left(\frac{v}{4\,l}\right) = 5\nu_1$	3
21	a) (ii) The momentum acquired by the gun and shot have the same magnitude. b)Recoil speed of the gun , $V = \frac{-mv}{M}$	1 2
22	a) The law is valid only for small deformation and it is obeyed only with in the elastic limit. b)  Fig. 2	1 2

23	1. A gas consists of a very large number of molecules which are perfectly identical elastic spheres. These molecules are in a state of continuous random motion in all directions with all possible velocities. 2. The size of each molecule is very small as compared to the distance between any two of them. Hence the volume occupied by all the molecules is negligible in comparison to the total volume of the gas. 3. There is no force of attraction or repulsion between the molecules and the walls of the container. 4. The collisions of the molecules amoung themselves and with the walls of the container are perfectly elastic. Therefore, momentum and kinetic energy of the molecules are conserved during collisions. (Any three)	3
24	(a) Angular speed decreases. (b) Conservation of Angular momentum. If the total external torque on a system of particles is zero, then the total angular momentum of the system is conserved.	1 2
25	 a)Simple pendulum consists of a bob of mass ‘m’, suspended from one end of an inextensible string of length ‘L’. The other end is fixed to a rigid support. The length of the pendulum is the distance between the rigid support and the centre of the bob. When the bob is pulled to one side and released the pendulum executes oscillations. At any instant ‘θ’ be the angular displacement. The weight of the bob ‘mg’ can be resolved into two components, mgsin θ→ directed towards mean position, mgcos θ→ in the direction of string. Here, ‘mgsin θ’ gives the restoring force. $ie \quad F=-mg\sin\theta=-mg\,\theta \qquad (as \quad \theta<<)$ $But \qquad \theta=\frac{x}{L}$ $\therefore \qquad F=-\left(\frac{mg}{L}\right)x$ Thus for small amplitude oscillations, the force is proportional to the displacement and directed towards mean position. Hence oscillations of simple pendulum is SHM. **<u>Period of oscillation of a simple pendulum:</u>** For a simple pendulum,	3

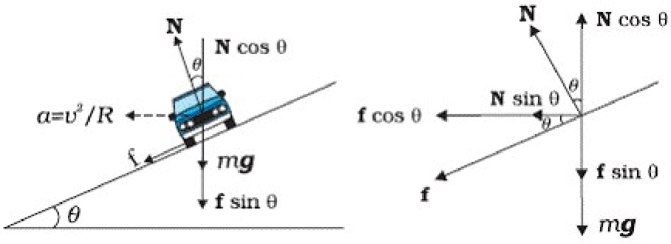
	$$F=-\left(\frac{mg}{L}\right)x \quad and$$ $$F=ma$$ $$\therefore \quad ma=-\left(\frac{mg}{L}\right)x$$ $$a=-\frac{gx}{L}$$ $$But \quad a=-\omega^2 x$$ $$\therefore \quad -\omega^2 x=-\frac{gx}{L}$$ $$\omega^2=\frac{g}{L}$$ $$\omega=\sqrt{\frac{g}{L}}$$ $$\frac{2\pi}{T}=\sqrt{\frac{g}{L}}$$ $$T=2\pi\sqrt{\frac{L}{g}}$$ This is the period of oscillation of a simple pendulum.	
26	a) **Expression for Maximum height(H):** We have $V^2=u^2+2as$ Taking the vertical components; $V_y^2=u_y^2+2a_y s_y$ Here Vy=0, u_y=usinθ , a_y=-g and S_y =H Therefore $0=(usin\theta)^2-2gH$ $2gH=u^2\sin^2\theta$ Maximum Height , $H=\frac{u^2\sin^2\theta}{2g}$ **Expression for Time of flight (T):** We have $S=ut+\frac{1}{2}at^2$ Taking vertical components; $S_y=u_y t+\frac{1}{2}a_y t^2$ Here S_y=0, u_y=usinθ , a_y=-g and t=T, time of flight. Therefore $0=u\sin\theta T-\frac{1}{2}gT^2$ $\frac{1}{2}gT^2=usin\theta T$ $\frac{1}{2}gT=usin\theta$ Time of flight $T=\frac{2u\sin\theta}{g}$	3

Answer any 3 questions from 27 to 31. Each carries 4 score

27	a)Yes. For example if a body is thrown up , at the highest point the velocity is zero but there is an acceleration downwards. b)  c)Second equation of motion OR Displacement time relation: From the graph Displacement S = Area under the graph AB = Area of rectangle OADE + Area of triangle ADB $= OA \times OE + \frac{1}{2} DB \times AD$ $= u \times t + \frac{1}{2}(v-u) \times t$ $= ut + \frac{1}{2} at \times t$ $S = ut + \frac{1}{2} at^2$ This is the displacement – time relation.	1 2 1
28	a) **At the point ‘A’:-** Kinetic Energy , KE =0 (because velocity u=0) Potential Energy , PE =mgh  **At the point ‘C’:-** Kinetic energy , KE = $\frac{1}{2} mv^2$ But $v^2 = 2gh$ (because u=0, a=g) Therefore , KE =mgh and PE = 0 This shows that the potential energy at the point A of the body is completely converted into kinetic energy at the point C b) Graph Showing the variation of KE, PE and TE with height for a freely falling body:	2

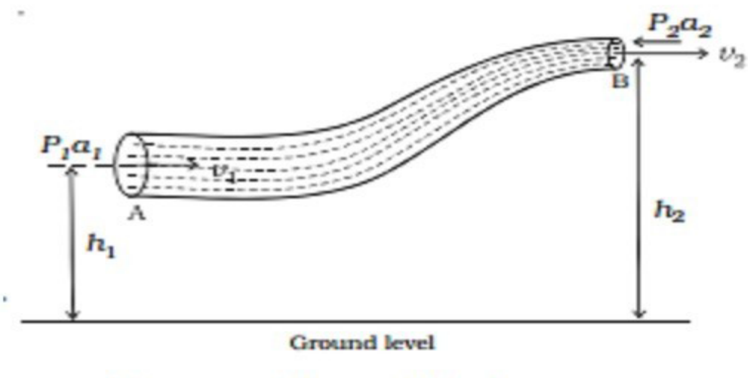
	 	2
29	a) Statement $I_z=I_x+I_y$ b) $I_x=I_y=I_d$ $I_z=2I_d$ $I_d=\frac{I_z}{2}$ $\quad I_d=\frac{\frac{MR^2}{2}}{2}$ $\quad I_d=\frac{MR^2}{4}$	2 2
30	a) Let M be the mass of earth and R is its radius. Let v_e be the velocity of a body of mass m with which it is to be projected so that it escapes from the gravitational field of earth. Kinetic energy near the surface of earth K.E= ½ m v_e^2 Potential energy of the body on the surface of earth , P . E = $\frac{-GMm}{R}$ Total energy of the body near the surface of earth, T . E = K . E + P . E = ½ m v_e^2 + $\frac{-GMm}{R}$ -------- (1) At infinity, K.E = P.E = 0. Therefore the total energy of the body at infinity = 0 -----(2) According to the law of conservation of energy, the total energy near the surface of earth is equal to the total energy at infinity. That is ½ m v_e^2 + $\frac{-GMm}{R}$ = 0 Or ½ m v_e^2 = $\frac{GMm}{R}$ or v_e = $\sqrt{\frac{2GM}{R}}$ -------- (3) Put G M = g R^2 in eq (3) we get, v_e = $\sqrt{\frac{2gR^2}{R}}$ = $\sqrt{2gR}$ ------ (4) b) $V_e=\sqrt{2}V_O$	3 1
31	a) decrease b)When the air bubble is inside the liquid, there is one surface- the water to air surface where the pressure increases. Hence the excess pressure inside the bubble is the increases in pressure across one surface $\Delta P=\frac{2T}{R}$	1 3

Answer any 2 questions from 32 to 34. Each carries 5 score

32	a)  Let R--> radius of circular path θ--> angle of banking μ_S -->Coefficient of friction. From the diagram $N\cos\theta = mg + f\sin\theta$ $N\cos\theta = mg + \mu_S N\sin\theta$ $N\cos\theta - \mu_S N\sin\theta = mg$ $N(\cos\theta - \mu_S\sin\theta) = mg$ Therefore $N = \frac{mg}{\cos\theta - \mu_S\sin\theta}$ -------------------(1) Similarly $\frac{mv^2}{R} = N\sin\theta + f\cos\theta$ $\frac{mv^2}{R} = N\sin\theta + \mu_S N\cos\theta$ $\frac{mv^2}{R} = N(\sin\theta + \mu_S\cos\theta)$ ----------------(2) Substituting (1) in (2) $\frac{mv^2}{R} = \frac{mg}{\cos\theta - \mu_S\sin\theta}(\sin\theta + \mu_S\cos\theta)$ $\frac{v^2}{R} = \frac{g(\sin\theta + \mu_S\cos\theta)}{(\cos\theta - \mu_S\sin\theta)}$ $v^2 = \frac{Rg(\sin\theta + \mu_S\cos\theta)}{(\cos\theta - \mu_S\sin\theta)}$ Therefore $v = \sqrt{\frac{Rg(\sin\theta + \mu_S\cos\theta)}{(\cos\theta - \mu_S\sin\theta)}}$ Dividing by cos θ, $v = \sqrt{\frac{Rg(\tan\theta + \mu_S)}{(1 - \mu_S\tan\theta)}}$ This is the safe velocity (maximum possible speed) for a vehicle on a banked road. b) $v = \sqrt{Rg(\tan\theta)}$	4 1
33	a)It states that "for the stream line flow of an ideal liquid, the total energy (sum of pressure energy, potential energy, and kinetic energy) per unit mass remains constant at every cross section through out the flow"	

$$\frac{P}{\rho}+\frac{V^2}{2}+gh \quad \text{or} \quad P+\frac{\rho v^2}{2}+\rho gh$$

This is the conservation law of energy for a flowing liquid.
Proof:



Let
P 1 --> pressure applied at A,
P 2 --> pressure at B,
a 1 --> area of cross section at A,
a 2 --> area of cross section at B,
h 1 --> mean height of section A
h 2 --> mean height of section B,
v 1 --> normal velocity of liquid at A
v 2 --> normal velocity of liquid at B.
ρ--> density of liquid.

Net work done per second on the liquid by the pressure energy in moving the liquid from section A to B = $P_1 V – P_2 V$

[By equation of continuity volume of liquid 'V' flowing per second remains constant]
The increase in potential energy /second of the liquid = mgh_2 -mgh_1

The increase in kinetic energy /second of the liquid = $\frac{1}{2} mv_2^2 - \frac{1}{2} mv_1^2$

According to work energy principle,
work done/second by the pressure energy= increase in PE/second + increase in KE/second.

$$P_1 V - P_2 V = mgh_2 - mgh_1 + \frac{1}{2} mv_2^2 - \frac{1}{2} mv_1^2$$

$$P_1 V + mgh_1 + \frac{1}{2} mv_1^2 = P_2 V + mgh_2 + \frac{1}{2} mv_2^2$$

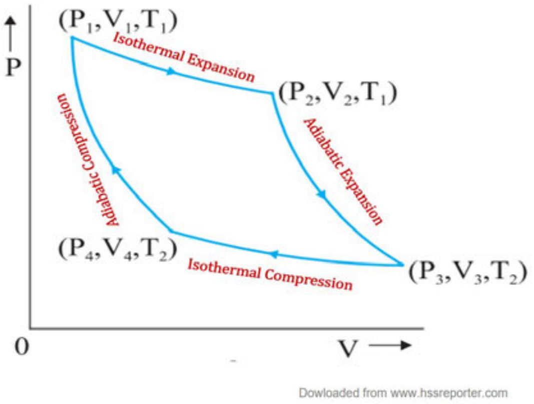
Dividing by 'm',

$$\frac{P_1 V}{m} + gh_1 + \frac{1}{2} v_1^2 = \frac{P_2 V}{m} + gh_2 + \frac{1}{2} v_2^2$$

$$\frac{P_1}{\rho} + gh_1 + \frac{1}{2} v_1^2 = \frac{P_2}{\rho} + gh_2 + \frac{1}{2} v_2^2$$

$$ie., \quad \frac{P}{\rho} + gh + \frac{1}{2} v^2 = constant.$$

4

	OR $P+\rho gh+\frac{\rho v^2}{2}=constant$ Thus, Pressure energy per unit mass+ PE per unit mass + KE per unit mass = a constant. This proves Bernoulli's theorem b) they will attract	1
34	a) heat engine b) & c) **Carnot cycle**  The four processes involved in carnot cycle are **1.Isothermal Expansion** **2. Adiabatic Expansion** **3. Isothermal Compression** **4. Adiabatic Compression** **Efficiency of Carnot Engine** $\eta = 1 - \frac{Q_2}{Q_1}$ $\eta = 1 - \frac{\mu RT_2 \ln\left\lvert\frac{V_3}{V_4}\right\rvert}{\mu RT_1 \ln\left\lvert\frac{V_2}{V_1}\right\rvert}$ As the two processes involved are adiabatic ,we get $\frac{V_3}{V_4}=\frac{V_2}{V_1}$ $\boldsymbol{\eta = 1 - \frac{T_2}{T_1}}$ $\boldsymbol{\eta = \frac{T_1 - T_2}{T_1}}$	1 2 1 1