JEE-MAIN 2025
Physics
Practice Test - 1

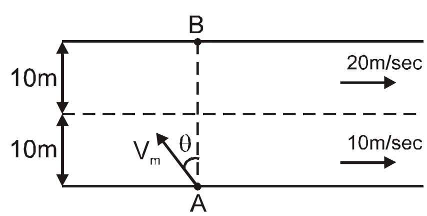
Date : **Time : 75 Min.** **Max. Marks : 80**

Marking Scheme :
SCQ - 1 - 3, (4, –1)
MCQ = 4 - 8, (4, –1)
Comprehension = 09 - 18, (4, –1)
Integer = 19 - 20 , (4, –1)

SECTION-1 : (Only One option correct type)

This section contains **3 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

1. In a river of 20 m width. Half part of river flows with speed 10 m/sec and remaining half part flows with 20 m/sec. as shown in figure. A man starts to swim from A and reaches to point B in 10 sec. Man swims with speed V_m with respect to river at an angle θ with line AB. Then, angle θ will be : (man swims with constant speed and in same direction with respect to river throughout the motion) :



(A) $\tan^{-1}(5)$ (B) $\tan^{-1}\left(\frac{15}{2}\right)$ (C) $\cos^{-1}\left(\frac{2}{15}\right)$ (D) $\tan^{-1}\left(\frac{1}{5}\right)$

2. A biker is initially at rest starts to move on a circular path of radius $R = \frac{200}{7}$ km with tangential acceleration $a = 1\text{m/sec}^2$ (constant in magnitude). If on an average bike runs 50 km/litre and initially bike has 2 litre petrol. The minimum value of coefficient of friction so that bike will not slip during motion is :

(A) $\frac{1}{\sqrt{3}}$ (B) $\frac{1}{\sqrt{2}}$ (C) $\frac{1}{2}$ (D) $\frac{1}{3}$

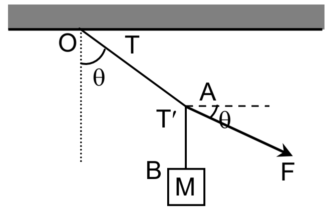
3. Two motor cars are moving along two roads perpendicular to each other towards point of intersection of the two roads. Their velocities at a particular time are V_1, V_2 respectively while their distance from the crossing are S_1 and S_2 respectively. If the acceleration of the two cars be f_1 and f_2 respectively, then they shall avoid collision, if

(A) $(S_1f_2 - S_2f_1)^2 \neq 2(V_2f_1 - V_1f_2)(V_2S_1 - V_1S_2)$
(B) $(S_1V_2 - S_2V_1)^2 \neq 2(f_1S_2 - f_2S_1)(V_2f_1 - V_1f_2)$
(C) $(V_2f_1 - V_1f_2)^2 \neq 2(S_1V_2 - S_2V_1)(f_1S_2 - f_2S_1)$
(D) $(S_1V_1 - S_2V_2)(f_1S_2 - f_1S_1)(V_2f_1 - V_1S_2) \neq 0$
(E) $(V_2f_1 - V_1f_2)^2 \neq 2(S_1V_2 - S_2V_1)(f_1S_2 + f_2S_1)$

SECTION-2 : (One or more option correct type)

This section contains **5 multiple choice question.** Each question has four choices (A), (B), (C) and (D) out of which **ONE or MORE** are correct.

4. One end of an ideal string is tied up with a fixed support and other end to a block of mass M as shown in figure. The string is pulled with a force F from point A. If the system remains in equilibrium as shown.



(A) the tension T in the string OA will be $F\cot\theta$.

(B) the tension T is the string OA will $Mg + F\sin\theta$.

(C) the tension T in the string OA will be $F\tan\theta + Mg\sec\theta$

(D) the tension T′ in part AB will be $Mg - F\sin\theta$.

5. A balloon is rising vertically from the ground in such a way that with high accuracy its acceleration is a linearly decreasing function of its altitude above the ground level. At the moment of release the velocity of the balloon is zero, and its acceleration is a_0. (Acceleration reduces to zero at height H) Then select the correct alternatives

(A) Maximum speed of the balloon is $\sqrt{a_0H}$.

(B) Maximum speed of the balloon is $\sqrt{2a_0H}$.

(C) The speed at altitude $\frac{H}{2}$ is $\sqrt{0.75a_0H}$.

(D) The balloon reaches at altitude H after a time $\frac{\pi}{2}\sqrt{\frac{H}{a_0}}$ from start.

6. A small object starts with a speed of v_0 = 20 m/s at the lowest point of a circular track of radius R = 8.16 m. The small object moves along the track. We have removed some part of circular track such that it resumes circular path from other side. Select correct alternatives. (Neglect friction, g = 9.8 m/s^2.)

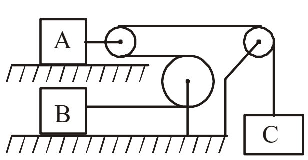
(A) The removed part of the circle subtends an angle $\frac{2\pi}{3}$ at the centre.

(B) The removed part of the circle subtends an angle $\frac{\pi}{3}$ at the centre.

(C) The time of free fall during the motion is approximately 2.23 second.

(D) Maximum height attained by particle from lowest point of circular path is more than 2R.

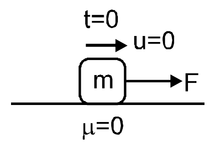
7. Find the acceleration of the three masses A, B and C shown in figure. Friction coefficient between all surfaces is 0.5. Pulleys are smooth. (Given m_A = 1kg, m_B = 1kg, m_C = 2kg.)



(A) $a_B = \frac{7g}{9}$ (B) $a_C = \frac{7g}{9}$ (C) $a_B = \frac{7g}{18}$ (D) $a_A = \frac{7g}{18}$

[Ans.a_1 = 7/18 g, a_2 = 7/9 g, a_3 = 0]

8. A body starts from rest on a smooth horizontal surface under the action of a constant horizontal force F and a resistance force $F_R = kv$ where k is a positive constant and v is instantaneous speed. Choose the correct option as a function of time t :



(A) Velocity achieved by body at time t is $V = \frac{F}{k}\left[1 - e^{-\frac{kt}{m}}\right]$

(B) Curve between velocity and time t and that between power of force F and time t are both straight line

(C) Power of force F increase continuously and becomes constant finally after long time

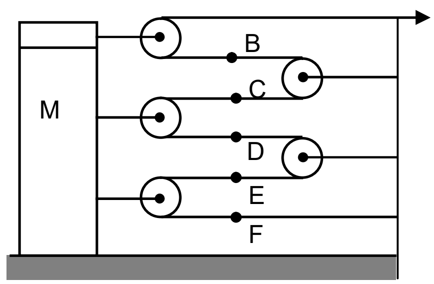
(D) Rate of change of power of force F decreases continuously and becomes zero finally after long time

SECTION – 3 : (Paragraph Type)

This section contains **3 paragraphs** each describing theory, experiment, data etc**. Ten questions** relate to three paragraphs. Each question of a paragraph has **only one correct answer** among the four choices (A), (B), (C) and (D).

Paragraph for Questions Nos. 09 to 11

In the given figure A block of mass m is pulled with the help of a string. All the surfaces are frictionless and radius of each frictionless and massless pulley is r. At any time t the velocity of point A on the string is v and points B, C, D, E & F lie on the line.



9. The magnitude of velocity of E with respect to A will be :

(A) 0 (B) 2v (C) v/3 (D) 2v/3

10. The magnitude of velocity of block with respect to A will be :

(A) v/6r (B) 5v/6 (C) v/2 (D) v

11. The angular velocity of line BE will be :

(A) v/6r (B) v/3r (C) 2v/3r (D) 2v/r

Paragraph for Questions Nos. 12 to 14

A nasty teenager is dropping tomatoes from a bridge onto cars on the road below. The height of the bridge (the point from which the tomatoes are dropped) is 10m above the ground. The teen first sees the cars when they are 50 m away. All cars drive at exactly the speed limit of 40 kilometers per hour. Assume that the tomatoes accelerate downward at 10 m/s^2.

12. How long after a car appears does she need to wait before dropping a tomato to hit the hood of the car at a height of 1.0 m above the ground ?

(A) 4.5 second (B) 3.16 second (C) 39 second (D) None of these

13. After some time, the teen gets bored with just dropping the tomatoes. As a challenge, she decides to throw the tomatoes straight up with some initial velocity, v_0, rather than just dropping them. Assume she throws the tomatoes 1.5 s after she sees the cars. What value of v_0 is needed for the tomatoes to hit the cars at the same height above the road ?

(A) 10 m/s (B) 12 m/s (C) 15 m/s (D) 15 km/h

14. Eventually, the teen gets bored with this new game and she decides to throw the tomatoes straight down at an initial velocity of 15 m/s. Now, how long does she need to wait after seeing the cars to hit them at the same height ?

(A) $\frac{1}{2}$ seconds (B) 3 seconds (C) 4.5 seconds (D*) 4 seconds

Paragraph for Questions Nos. 15 to 18

A fighter plane flies at a velocity of 300 m/sec. On the fighter plane there is a gun which shoots at a rate of 40 rounds per second with a muzzle velocity of 1200 m/sec. The shots are aimed at another fighter plane flying at a velocity of 200 m/sec. The rate (in round per second) at which the projectiles hit the target plane.

15. When the two planes move in the same direction and the target plane is in front of the shooting plane.

(A) 40 (B) 36.66 (C) 43.33 (D) None of these

16. When the two planes move in the same direction and the target plane is at the rear of the shooting plane.

(A) 42.33 (B) 36.66 (C) 43.33 (D) 56.67

17. When the two planes move towards one another.

(A) 42.33 (B) 36.66 (C) 43.33 (D) 56.67

18. When the two planes move away from one another.

(A) 20.33 (B) 23.33 (C) 26.33 (D) 31.33

SECTION-4 : (Integer value correct Type)

This section contains **2 questions**. The answer to each question is a **single digit integer,** ranging from 0 to 9 (both inclusive)

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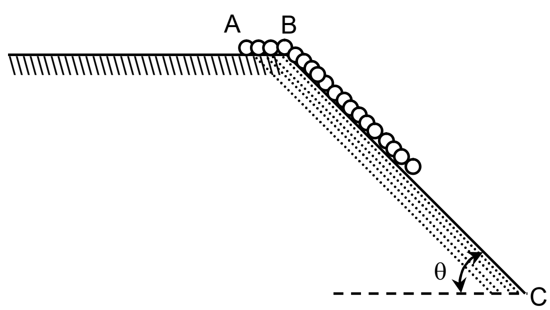
19. A chain of length L and mass m is placed upon a smooth surface (see figure). The length of $\overline{BA}$ is (L – b). If the velocity of the chain when its end reaches B is $\sqrt{g\sin\theta\left(L-\frac{b^2}{\beta L}\right)}$. Find β.



20. The speed of a motorboat in still water is four times the speed of a river. Normally, the motorboat takes one minute to cross the river to the port straight across on the other bank. One time, due to a motor problem, it was not able to run at full power, and it took four minutes to cross the river along the same path. If the ratio of later speed of boat to initial speed of boat is $\frac{1}{4\beta}\sqrt{31}$. Calculate β.

ANSWER KEYS

1.	(B)	**2.**	(B)	**3.**	(A)	**4.**	(AC)	**5.**	(ACD)
6.	(ACD)	**7.**	(BD)	**8.**	(ACD)	**9.**	(D)	**10.**	(B)
11.	(A)	**12.**	(B)	**13.**	(B)	**14.**	(D)	**15.**	(C)
16.	(B)	**17.**	(D)	**18.**	(B)	**19.**	1	**20.**	4

SOLUTIONS

Solutions:

Sol.1 $10(V_m\cos\theta) = 20$

$V_m\cos\theta = 2$m/sec

$V_m\sin\theta = 15$ m/sec.

$\tan\theta = \frac{15}{2}$

Sol.2 In 2 litre he has to go 100 km.
So, final speed of bike will be

$v^2 = 2 \times 1 \times 100 \times 10^3$ ....(i)

Now finally,

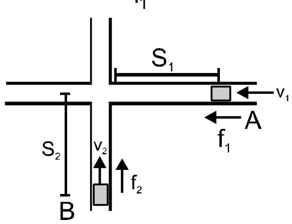
$$\mu^2 g^2 = a^2 + \left(\frac{v^2}{R}\right)^2$$

$\mu^2 .100 = 1 + 49$

$\mu = \frac{1}{\sqrt{2}}$.

Sol.3 $S_1 = V_1 t + \frac{1}{2} f_1 t^2$

(A) $t_1 = \frac{\sqrt{V_1^2 + 2f_1S_1} - V_1}{f_1}$



(B) $t_2 = \frac{\sqrt{V_2^2 + 2f_2S_2} - V_2}{f_2}$

For no collision, $t_1 \neq t_2$.

Sol.4 $T\sin\theta = F\cos\theta$

$T\cos\theta = F\sin\theta + T'$

$T' = Mg$

Sol.5 With a good approximation the balloon in the problem performs a harmonic oscillation motion, since its acceleration is proportional to its height measured from the altitude H, and has opposite direction. Through this analogy the kinematics equations of the balloon are similar to those of a harmonic motion. The kinematics of the harmonic motion is uniquely determined by its amplitude A and its maximum acceleration a_{max}. This exact data is given in the problem.

$A = H$ and $a_{max} = a_0$

In the first question the speed at the altitude H is just the maximum speed of the oscillation. The maximum velocity and maximal acceleration of the harmonic motion can be expressed using the angular frequency :

$$u_{max} = A\omega,$$
$$a_{max} = A\omega^2$$

From here, the angular frequency can be expressed using the known data :

$$\omega = \sqrt{\frac{a_{max}}{A}}$$

So, using the previous notations, the unknows speed at altitude H is :

$$v(H) = v_{max} = A\sqrt{\frac{a_{max}}{A}} = \sqrt{a_{max}A} = \sqrt{a_0 H}$$

b) the speed at altitude H/2 can be determined by the known formula :

$$v = \omega\sqrt{A^2 - y^2}$$

so $$v = \sqrt{\frac{a_0}{H}}\sqrt{H^2 - \left(\frac{H}{2}\right)^2} = \sqrt{0.75a_0 H}$$

c) The time in question is one quarter of the period of the harmonic oscillation, so :

$$t = \frac{T}{4} = \frac{2\pi}{4\omega} = \frac{\pi}{2}\sqrt{\frac{H}{a_0}}$$

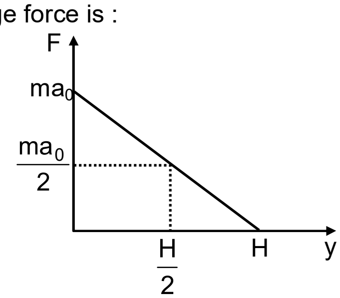
Another solution (for the questions concerning the speed) is based on the work energy theorem.
Since the net force acting on the balloon is linearly decreasing to zero with the altitude, the force averaged over the altitude is just half of the maximal force.
The change of the kinetic energy is equal to the work done by this force :

$$\frac{ma_0}{2}H = \frac{1}{2}mv^2,$$

thus, the speed at height H is :

$$v(H) = \sqrt{a_0 H}.$$

From ground level to H/2 the average force is :



$$\frac{ma_0 + \frac{ma_0}{2}}{2} = 0.75ma_0$$

so the speed at height H/2 is

$$v = \sqrt{0.75a_0 H}$$

The simplest, most elementary way to determine the time needed for the balloon to rise is to apply the analogy to the harmonic oscillation.

Sol.6 Let us describe the instantaneous position of the object with the angle α between the vertical and the radius drawn to the small object. Where the wall ends, the object undergoes projectile motion with a initial angle of α as well. The omission of some part of the wall does not lead to the failure of the trick if the downward part of the parabola smoothly fits to the circle again. From this, it is derived that the missing part of the circular track must be symmetrical along the vertical diameter of the circle. This condition can be considered as the horizontal component of the displacement of the object during the time of the ascent of the object (half of the range of the projectile motion) and is the same as the half of the chord which belongs to the arc cut off the circle. Let us determine the central angle subtended by the arc cut off. Let the magnitude of this angle be 2α. The time of the ascent of the projectile motion is :

$$t_a = \frac{v\sin\alpha}{g}$$

The distance covered in x direction during this time is :

$$v\cos\alpha \cdot t_a = \frac{v\cos\alpha \cdot v\sin\alpha}{g} = R\sin\alpha$$

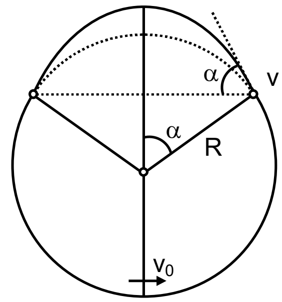
From this $\cos\alpha = \frac{Rg}{v^2}$

The initial speed of the projectile motion can be calculated using the work-energy theorem :

$$-mgR(1+\cos\alpha) = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$$

from which : $v^2 = v_0^2 - 2gR(1+\cos\alpha)$, and $\cos\alpha = \frac{Rg}{v_0^2 - 2Rg(1+\cos\alpha)}$

This is a quadratic equation for the cosine of half of the asked angle :



$$\cos^2\alpha + \left(1 - \frac{v_0^2}{2Rg}\right)\cos\alpha + \frac{1}{2} = 0$$

In this case $\frac{v_0^2}{2Rg} = \frac{400}{2\times 8.16\times 9.8}$ =2.5, which can be substituted into the equation, such that :

$$\cos^2\alpha - 1.5\cos\alpha + \frac{1}{2} = 0$$

for which 2 solutions are gained for cos α :

$\cos\alpha_1 = 1$, and $\cos\alpha_2 = 0.5$

The solution for the central angle of the arc which is to cut off are : $\varphi_1 = 2\alpha_1 = 0^\circ$ and $\varphi_2 = 2\alpha_2 = 120^\circ$, so the length of the circular path is :

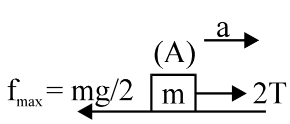
$$i = R\varphi = \frac{2\pi}{3}R = 17.15\text{m}$$

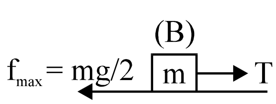
Time of flight for projectile motion

$$T = \frac{2u\sin\alpha}{g} = \frac{2\times\sqrt{V_0^2 - 2gr(1+\cos\alpha)}}{g}\sin\alpha$$

$$= \frac{2}{9.8}\times\sqrt{400 - 2\times 9.8\times 8.16\left(1+\frac{1}{2}\right)}\times\frac{\sqrt{3}}{2}$$ = **2.23 Ans.**

Sol.7





Suppose only block (A) and (B) move

$2T - \frac{mg}{2}$ = ma

2mg – T = 2m . 2a

3.5mg = 9 ma

a = $\frac{7}{18}$ g & 2a = $\frac{7}{9}$ g

$T = 2mg - 2m \cdot \frac{7g}{9} = \frac{4}{9}mg < \frac{mg}{2}$

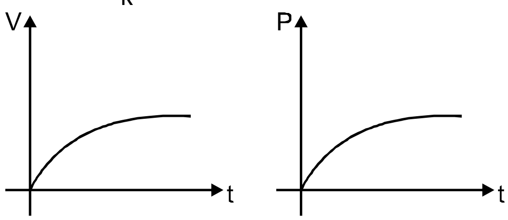
Sol.8 $F - kv = ma$

$F - kv = m\frac{dv}{dt}$

$\int_0^v \frac{dv}{F-kv} = \frac{1}{m}\int_0^t dt$

$V = \frac{F}{k}\left(1 - e^{-\frac{kt}{m}}\right)$

$P = FV = \frac{F^2}{k}\left(1 - e^{-\frac{kt}{m}}\right)$



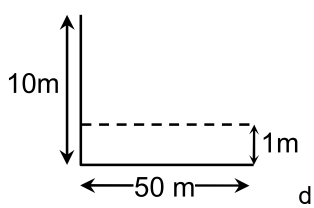
$\frac{dP}{dt} = F\frac{dV}{dt}$.

Sol.9 Velocity of E

$v_E = \frac{v}{3}$

$v_{EA} = v_E - v_A = \frac{v}{3} - v = \frac{-2v}{3}$

Sol.12



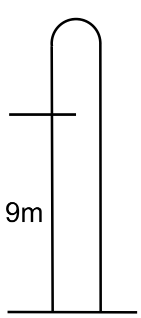
$t_0 = t_0 = \frac{50}{\left(\frac{100}{9}\right)} = \frac{9}{2} = 4.5\,\text{seconds}$

$h = 10 - 1 = 9$ m

$t \ t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times 9}{10}} = \frac{3\sqrt{2}}{\sqrt{10}} = 1.34\,\text{seconds}$

$\Delta t = 4.5 - 1.34 = 3.16$ seconds

Sol.13

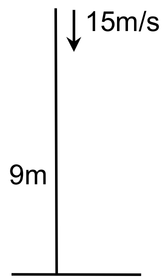


$t = 4.5 - 1.5 = 3$ seconds

$9 = -V_0 t + \frac{1}{2}\times 10 \times t^2$

$9 = -V_0 \times 3 + 5 \times 9$
$3V_0 = 5 \times 9 - 9 = 4 \times 9$
$\therefore V_0 = 4 \times 3 = 12$ m/s

Sol.14



$9 = 15t + \frac{1}{2}gt^2$
$9 = 15t + 5t^2$
$\Rightarrow 5t^2 + 15t - 9 = 0$
$\Rightarrow t = \frac{-15 \pm \sqrt{405}}{10}$
$= \frac{-15 + 20.12}{10} = \frac{5.12}{10}$
$= 0.512$ seconds $\simeq 0.5$ seconds
$\Delta t = 4.5 - 0.512$
$= 3.988 \simeq 4$ seconds

Sol. **(15 to 18)**

Denote by ν_s the velocity of the plane from which the shots are fired, by ν_t the velocity of the target plane and by L the distance between them at the certain moment of time when the shooting plane starts to shoot. Denotes by r the rate of fire of the gun and by ν the muzzle velocity.

15. The time it takes for the first projectile to reach the target plane is

$t_1 = \frac{L}{\nu + \nu_s - \nu_t}$

After a time of $\frac{1}{r}$ the second projectile is shot and the distance between the planes at this time is given by : $L' = L - \frac{\nu_s - \nu_t}{r}$

Thus, the time it takes second projectile to arrive at the target plane is

$t_2 = \frac{L - \frac{\nu_s - \nu_t}{r}}{\nu + \nu_s - \nu_t}$

Which is

$\Delta t = t_2 + \frac{1}{r} - t_1 = \frac{1}{r} - \frac{\nu_s - \nu_t}{r\left(\nu + \nu_s - \nu_t\right)} = \frac{\nu}{r\left(\nu + \nu_s - \nu_t\right)}$

After the first shot, the time increment does not depend on the initial distance, thus the rate of hitting is

$r' = \frac{1}{\Delta t} = r\frac{\left(\nu + \nu_s - \nu_t\right)}{\nu} = 40 \times \frac{1300}{1200} = 43.33$ hits/sec.

16. Using the same reasoning for this case, we obtain :

$r' = r\frac{\nu - \nu_s + \nu_t}{\nu} = 40 \times \frac{1100}{1200} = 36.66$ hits/sec.

17. In this case

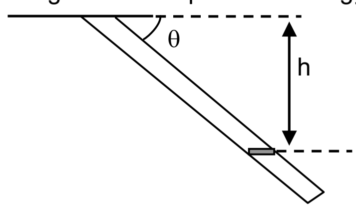
$r' = r\frac{\nu + \nu_s + \nu_t}{\nu} = 40 \times \frac{1700}{1200} = 56.67$ hits/sec.

18. Here

$r' = r\frac{\nu - \nu_s - \nu_t}{\nu} = 40 \times \frac{700}{1200} = 23.33$ hits/sec.

Comment :
The phenomenon described in this problem are called the 'Classical Doppler effect'. One observes that the Doppler effect is not associated exclusively with wave motion, but is a much more general phenomenon.

Sol.19 To solve this problem, we use the principle of conservation of energy. Let us denote by y = 0 the plane $\overline{AB}$. It will be the reference plane of the potential energy. In changing its position from A to B the chain's potential energy changes and as a result its velocity changes. The potential energy is calculated by integration over the length of the chain. The mass of the chain per unit length is $\lambda = \frac{m}{L}$. The contribution of a piece of length dr to the potential energy is du = – gh dm = – λhg dr



where h = r sin θ (see figure) the initial potential energy is, therefore

$$u_i = \int_0^b (-\lambda g \sin\theta) r \ \ dr = -\frac{1}{2}\lambda g b^2 \sin\theta$$

Similarly, the final potential energy is

$$u_f = \int_0^L (-\lambda g \sin\theta) r \ \ dr = -\frac{1}{2}\lambda g L^2 \sin\theta$$

From the principle of conservation of energy, we know that

$E_{k(i)} + u_i = E_{k(f)} + u_f$

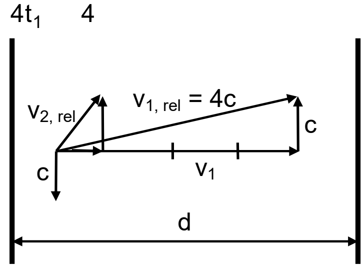
where $E_{k(i)} = 0$ hence

$$E_{k(f)} = u_i - u_f = \frac{1}{2}\frac{m}{L} g \sin\theta \,(L^2 - b^2) = \frac{1}{2} mv^2$$

from which follows $\nu = \sqrt{g \sin\theta \left(L - \frac{b^2}{L}\right)}$

Sol.20 Let d and c denote the width and speed of the river. Let v_0 and v_2 be the speeds of the boat relative to the ground in the two cases, and let $4c = v_{1_{rel}}$ and $v_{2_{rel}}$ denote its speeds relative to the water. The task is to find the ratio $v_{2_{rel}} / v_{1_{rel}}$. In both cases, the component parallel to the riverbanks is equal to c. The speed s of the boat relative to the ground in the two cases are

$$v_1 = \frac{d}{t_1}, \text{ and } v_2 = \frac{d}{t_2} = \frac{d}{4t_1} = \frac{v_1}{4}$$



As shown in the figure, the speeds are related as follows :

$$v_{2_{rel}}^2 = c^2 + v_2^2 = c^2 + \frac{v_1^2}{16}$$

Since, $v_{1_{rel}}^2 = c^2 + v_1^2 = (4c)^2 = 16c^2$, it follows that $v_1^2 = 15c^2$. Thus, from (1), the speed relative to the water, of the boat with its motor broken down is

$$v_{2_{rel}}^2 = c^2 + \frac{15}{16}c^2 = \frac{31}{16}c^2,$$

and the ratio in question is $\frac{v_{2_{rel}}}{v_{1_{rel}}} = \sqrt{\frac{31c^2/16}{16c^2}} = \frac{1}{16}\sqrt{31} = 0.348$