JEE ADVANCED (Paper - 2)

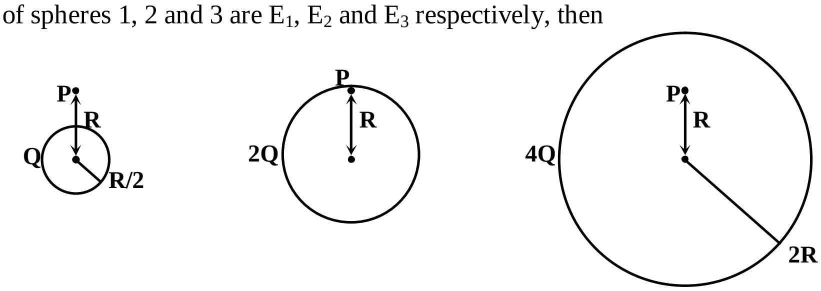
Code - 8

PHYSICS

SECTION – 1 : (Only One Option Correct Type)

This section contains 10 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONLY ONE option is correct.

1. Charges Q, 2Q and 4Q are uniformly distributed in three dielectric solid spheres 1, 2 and 3 of radii R/2, R and 2R respectively, as shown in figure. If magnitudes of the electric fields at point P at a distance R from the centre of spheres 1, 2 and 3 are E_1, E_2 and E_3 respectively, then



Sphere 1 **Sphere 2** **Sphere 3**

(A) $E_1 > E_2 > E_3$ (A) $E_3 > E_1 > E_2$ (C) $E_2 > E_1 > E_3$ (D) $E_3 > E_2 > E_1$

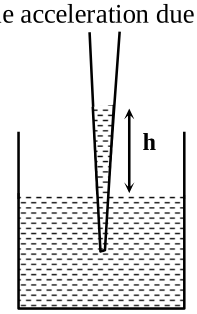
*2. A glass capillary tube is of the shape of truncated cone with an apex angle α so that its two ends have cross sections of different radii. When dipped in water vertically, water rises in it to a height h, where the radius of its cross section is b. If the surface tension of water is S, its density is ρ, and its contact angle with glass is θ, the value of h will be (g is the acceleration due to gravity)

(A) $\frac{2S}{b\rho g}\cos(\theta-\alpha)$

(B) $\frac{2S}{b\rho g}\cos(\theta+\alpha)$

(C) $\frac{2S}{b\rho g}\cos(\theta-\alpha/2)$

(D) $\frac{2S}{b\rho g}\cos(\theta+\alpha/2)$

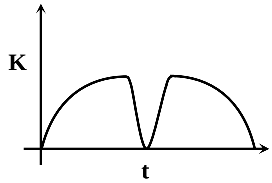


3. If λ_{cu} is the wavelength of K_α X-ray line of copper (atomic number 29) and λ_{Mo} is the wavelength of the K_α X-ray line of molybdenum (atomic number 42), then the ratio $\lambda_{cu}/\lambda_{Mo}$ is close to
(A) 1.99 (B) 2.14 (C) 0.50 (D) 0.48

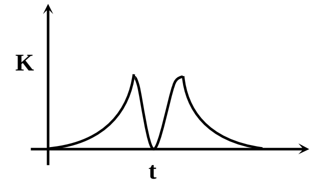
*4. A planet of radius R = $\frac{1}{10}$ × (radius of Earth) has the same mass density as Earth. Scientists dig a well of depth $\frac{R}{5}$ on it and lower a wire of the same length and of linear mass density 10^{-3} kgm^{-1} into it. If the wire is not touching anywhere, the force applied at the top of the wire by a person holding it in place is (take the radius of Earth = 6×10^6 m and the acceleration due to gravity of Earth is 10 ms^{-2})
(A) 96 N (B) 108 N (C) 120 N (D) 150 N

*5. A tennis ball is dropped on a horizontal smooth surface. It bounces back to its original position after hitting the surface. The force on the ball during the collision is proportional to the length of compression of the ball. Which one of the following sketches describes the variation of its kinetic energy K with time t most appropriately? The figures are only illustrative and not to the scale.

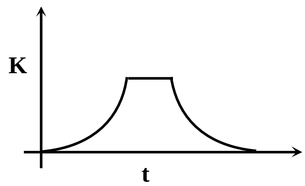
(A)



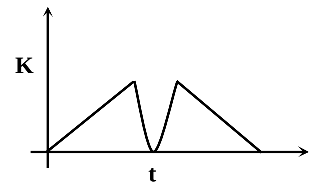
(B)



(C)



(D)

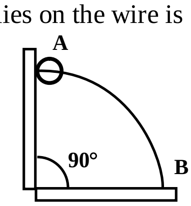


6. A metal surface is illuminated by light of two different wavelengths 248 nm and 310 nm. The maximum speeds of the photoelectrons corresponding to these wavelengths are u_1 and u_2, respectively. If the ratio $u_1 : u_2 = 2 : 1$ and hc = 1240 eV nm, the work function of the metal is nearly

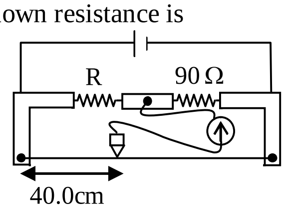
(A) 3.7 eV (B) 3.2 eV (C) 2.8 eV (D) 2.5 eV

*7. A wire, which passes through the hole in a small bead, is bent in the form of quarter of a circle. The wire is fixed vertically on ground as shown in the figure. The bead is released from near the top of the wire and it slides along the wire without friction. As the bead moves from A to B, the force it applies on the wire is

(A) always radially outwards.
(B) always radially inwards.
(C) radially outwards initially and radially inwards later.
(D) radially inwards initially and radially outwards later.



8. During an experiment with a metre bridge, the galvanometer shows a null point when the jockey is pressed at 40.0 cm using a standard resistance of 90 Ω, as shown in the figure. The least count of the scale used in the metre bridge is 1 mm. The unknown resistance is

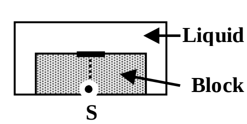


(A) 60 ± 0.15Ω (B) 135 ± 0.56Ω (C) 60 ± 0.25Ω (D) 135 ± 0.23Ω

9. Parallel rays of light of intensity $I = 912\ Wm^{-2}$ are incident on a spherical black body kept in surroundings of temperature 300 K. Take Stefan-Boltzmann constant $\sigma = 5.7\times10^{-8}\ Wm^{-2}K^{-4}$ and assume that the energy exchange with the surroundings is only through radiation. The final steady state temperature of the black body is close to

(A) 330 K (B) 660 K (C) 990 K (D) 1550 K

10. A point source S is placed at the bottom of a transparent block of height 10 mm and refractive index 2.72. It is immersed in a lower refractive index liquid as shown in the figure. It is found that the light emerging from the block to the liquid forms a circular bright spot of diameter 11.54 mm on the top of the block. The refractive index of the liquid is



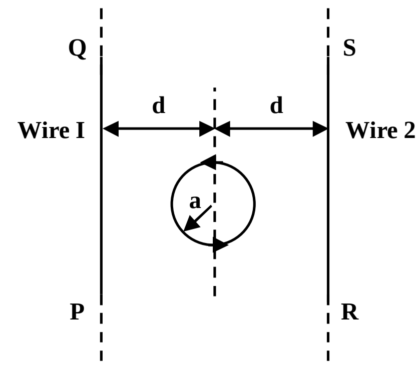
(A) 1.21 (B) 1.30 (C) 1.36 (D) 1.42

SECTION – 2 : Comprehension type (Only One Option Correct)

This section contains 3 paragraphs, each describing theory, experiments, data etc. Six questions relate to the three paragraphs with two questions on each paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D).

Paragraph for Questions 11 & 12

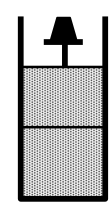
The figure shows a circular loop of radius *a* with two long parallel wires (numbered 1 and 2) all in the plane of the paper. The distance of each wire from the centre of the loop is *d*. The loop and the wires are carrying the same current I. The current in the loop is in the counterclockwise direction if seen from above.



11. When d ≈ a but wires are not touching the loop, it is found that the net magnetic field on the axis of the loop is zero at a height h above the loop. In that case
(A) current in wire 1 and wire 2 is the direction PQ and RS, respectively and h ≈ a
(B) current in wire 1 and wire 2 is the direction PQ and SR, respectively and h ≈ a
(C) current in wire 1 and wire 2 is the direction PQ and SR, respectively and h ≈ 1.2a
(D) current in wire 1 and wire 2 is the direction PQ and RS, respectively and h ≈ 1.2a

12. Consider d >> a, and the loop is rotated about its diameter parallel to the wires by 30° from the position shown in the figure. If the currents in the wires are in the opposite directions, the torque on the loop at its new position will be (assume that the net field due to the wires is constant over the loop)
(A) $\frac{\mu_0 I^2 a^2}{d}$ (B) $\frac{\mu_0 I^2 a^2}{2d}$ (C) $\frac{\sqrt{3}\mu_0 I^2 a^2}{d}$ (D) $\frac{\sqrt{3}\mu_0 I^2 a^2}{2d}$

Paragraph for Questions 13 & 14



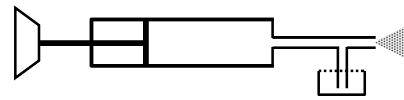
In the figure a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat. The lower compartment of the container is filled with 2 moles of an ideal monatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. The heat capacities per mole of an ideal monatomic gas are $C_V = \frac{3}{2}R,\ C_P = \frac{5}{2}R$, and those for an ideal diatomic gas are $C_V = \frac{5}{2}R,\ C_P = \frac{7}{2}R$.

*13. Consider the partition to be rigidly fixed so that it does not move. When equilibrium is achieved, the final temperature of the gases will be
(A) 550 K (B) 525 K (C) 513K (D) 490 K

*14. Now consider the partition to be free to move without friction so that the pressure of gases in both compartments is the same. Then total work done by the gases till the time they achieve equilibrium will be
(A) 250 R (B) 200 R (C) 100 R (D) –100 R

Paragraph for Questions 15 & 16

A spray gun is shown in the figure where a piston pushes air out of a nozzle. A thin tube of uniform cross section is connected to the nozzle. The other end of the tube is in a small liquid container. As the piston pushes air through the nozzle, the liquid from the container rises into the nozzle and is sprayed out. For the spray gun shown, the radii of the piston and the nozzle are 20 mm and 1 mm respectively. The upper end of the container is open to the atmosphere.



*15. If the piston is pushed at a speed of 5 mms^{-1}, the air comes out of the nozzle with a speed of

(A) 0.1 ms^{-1} (B) 1 ms^{-1} (C) 2 ms^{-1} (D) 8 ms^{-1}

*16. If the density of air is ρ_a and that of the liquid ρ_ℓ, then for a given piston speed the rate (volume per unit time) at which the liquid is sprayed will be proportional to

(A) $\sqrt{\frac{\rho_a}{\rho_\ell}}$ (B) $\sqrt{\rho_a \rho_\ell}$ (C) $\sqrt{\frac{\rho_\ell}{\rho_a}}$ (D) ρ_ℓ

SECTION – 3: Match List Type (Only One Option Correct)

This section contains four questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as option (A), (B), (C) and (D) out of which one is correct.

*17. A person in a lift is holding a water jar, which has a small hole at the lower end of its side. When the lift is at rest, the water jet coming out of the hole hits the floor of the lift at a distance d of 1.2 m from the person. In the following, state of the lift's motion is given in List I and the distance where the water jet hits the floor of the lift is given in List II. Match the statements from List I with those in List II and select the correct answer using the code given below the lists.

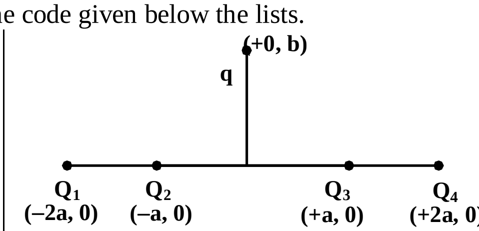
	List I		List II
P.	Lift is accelerating vertically up.	**1.**	d = 1.2 m
Q.	Lift is accelerating vertically down with an acceleration less than the gravitational acceleration.	**2.**	d > 1.2 m
R.	Lift is moving vertically up with constant speed.	**3.**	d < 1.2 m
S.	Lift is falling freely.	**4.**	No water leaks out of the jar

Code:

(A) P-2, Q-3, R-2, S-4
(B) P-2, Q-3, R-1, S-4
(C) P-1, Q-1, R-1, S-4
(D) P-2, Q-3, R-1, S-1

18. Four charges Q_1, Q_2, Q_3 and Q_4 of same magnitude are fixed along the x axis at x = -2a, –a, +a and +2a, respectively. A positive charge q is placed on the positive y axis at a distance b > 0. Four options of the signs of these charges are given in List I. The direction of the forces on the charge q is given in List II. Match List I with List II and select the correct answer using the code given below the lists.

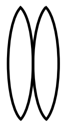
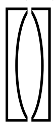
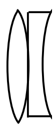
	List I		List II
P.	Q_1, Q_2, Q_3 Q_4 all positive	**1.**	+x
Q.	Q_1, Q_2 positive; Q_3, Q_4 negative	**2.**	–x
R.	Q_1, Q_4 positive ; Q_2, Q_3 negative	**3.**	+y
S.	Q_1, Q_3 positive; Q_2, Q_4 negative	**4.**	–y



Code:

(A) P-3, Q-1, R-4, S-2 (B) P-4, Q-2, R-3, S-1
(C) P-3, Q-1, R-2, S-4 (D) P-4, Q-2, R-1, S-3

19. Four combinations of two thin lenses are given in List I. The radius of curvature of all curved surfaces is r and the refractive index of all the lenses is 1.5. Match lens combinations in List I with their focal length in List II and select the correct answer using the code given below the lists.

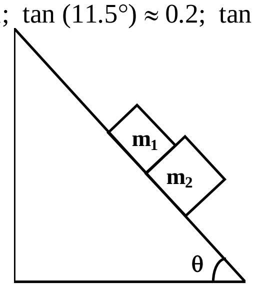
	List I		List II
P.		**1.**	2r
Q.		**2.**	r/2
R.		**3.**	–r
S.		**4.**	r

Code:

(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-4, R-3, S-1
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-1, R-3, S-4

*20. A block of mass m_1 = 1 kg another mass m_2 = 2kg, are placed together (see figure) on an inclined plane with angle of inclination θ. Various values of θ are given in List I. The coefficient of friction between the block m_1 and the plane is always zero. The coefficient of static and dynamic friction between the block m_2 and the plane are equal to μ = 0.3. In List II expressions for the friction on the block m_2 are given. Match the correct expression of the friction in List II with the angles given in List I, and choose the correct option. The acceleration due to gravity is denoted by g.

[**Useful information:** tan (5.5°) ≈ 0.1; tan (11.5°) ≈ 0.2; tan (16.5°) ≈ 0.3]



	List I		List II
P.	θ = 5°	**1.**	$m_2 g \sin\theta$
Q.	θ = 10°	**2.**	$(m_1+m_2)\, g \sin\theta$
R.	θ = 15°	**3.**	$\mu m_2 g \cos\theta$
S.	θ = 20°	**4.**	$\mu(m_1 + m_2) g \cos\theta$

Code:

(A) P-1, Q-1, R-1, S-3
(B) P-2, Q-2, R-2, S-3
(C) P-2, Q-2, R-2, S-4
(D) P-2, Q-2, R-3, S-3

ANSWERS

PAPER-2 [Code – 8]
JEE(ADVANCED) 2014

PHYSICS

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

HINTS AND SOLUTIONS

PHYSICS

1. For point outside dielectric sphere $E = \frac{Q}{4\pi\varepsilon_0 r^2}$

For point inside dielectric sphere $E = E_s \frac{r}{R}$

Exact Ratio $E_1 : E_2 : E_3 = 2 : 4 : 1$

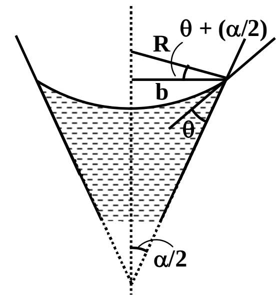
2. If R be the meniscus radius

$R\cos(\theta + \alpha/2) = b$

Excess pressure on concave side of meniscus = $\frac{2S}{R}$

$$h\rho g = \frac{2S}{R} = \frac{2S}{b}\cos\left(\theta + \frac{\alpha}{2}\right)$$

$$\Rightarrow \quad h = \frac{2S}{b\rho g}\cos\left(\theta + \frac{\alpha}{2}\right)$$



3. $$\frac{\lambda_{Cu}}{\lambda_{Mo}} = \left(\frac{Z_{Mo} - 1}{Z_{Cu} - 1}\right)^2$$

4. Inside planet

$$g_i = g_s \frac{r}{R} = \frac{4}{3}G\pi r\rho$$

Force to keep the wire at rest (F)

= weight of wire

$$= \int_{4R/5}^{R} (\lambda dr)\left(\frac{4}{3}G\pi r\rho\right) = \left(\frac{4}{3}G\pi\rho\right)\left(\frac{9\lambda}{50}\right)R^2$$

Here, ρ = density of earth = $\frac{M_e}{\frac{4}{3}\pi R_e^2}$

Also, $R = \frac{R_e}{10}$; putting all values, F = 108 N

5. $$\frac{d(KE)}{dt} = mv\frac{dv}{dt}$$

6. $$\frac{\frac{hc}{\lambda_1} - \phi}{\frac{hc}{\lambda_2} - \phi} = \frac{u_1^2}{u_2^2}$$

$\phi = 3.7$ eV

7. Initially bead is applying radially inward normal force.

During motion at an instant, N = 0, after that N will act radially outward.

8. $R = \frac{x}{100 - x} 90$

$\therefore\ R = 60\,\Omega$

$\frac{dR}{R} = \frac{100}{(x)(100 - x)} dx$

$\therefore\ dR = \frac{100}{(40)(60)} 0.1 \times 60$

$= 0.25\Omega$

Alternatively

$\frac{dR}{R} = \frac{0.1}{40} + \frac{0.1}{60}$

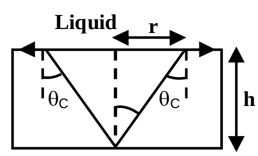
$\therefore\ dR = 0.25\Omega$

9. Rate of radiation energy lost by the sphere
= Rate of radiation energy incident on it

$\Rightarrow\ \sigma \times 4\pi r^2 \left[T^4 - (300)^4\right] = 912 \times \pi r^2$

$\Rightarrow\ T = \sqrt{11} \times 10^2 \approx 330\ K$

10. $\tan\theta_C = \frac{r}{h} = \frac{5.77}{10} \approx \sqrt{3}$



$\Rightarrow\ \theta_C = 30°$

$\Rightarrow \sin\theta_C = \frac{\mu_\ell}{\mu_b}$

$\Rightarrow \mu_\ell = 2.72 \times \frac{1}{2} = 1.36$

11. The net magnetic field at the given point will be zero if.

$\left|\vec{B}_{wires}\right| = \left|\vec{B}_{loop}\right|$

$\Rightarrow\ 2\frac{\mu_0 I}{2\pi\sqrt{a^2 + h^2}} \times \frac{a}{\sqrt{a^2 + h^2}} = \frac{\mu_0 I a^2}{2(a^2 + h^2)^{3/2}}$

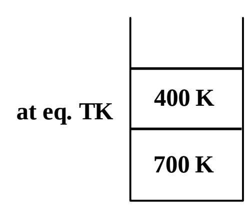
$\Rightarrow\ h \approx 1.2\ a$

The direction of magnetic field at the given point due to the loop is normally out of the plane. Therefore, the net magnetic field due the both wires should be into the plane. For this current in wire I should be along PQ and that in wire RS should be along SR.

12. $\tau = MB\sin\theta = I\pi a^2 \times 2 \times \frac{\mu_0 I}{2\pi d} \sin 30° = \frac{\mu_0 I^2 a^2}{2d}$

13. Heat given by lower compartment = $2 \times \frac{3}{2} R \times (700 - T)$ ...(i)

Heat obtained by upper compartment = $2 \times \frac{7}{2} R \times (T - 400)$ ...(ii)



equating (i) and (ii)

3 (700 – T) = 7 (T – 400)

2100 – 3T = 7 T – 2800

4900 = 10 T $\Rightarrow$ T = 490 K

14. Heat given by lower compartment = $2 \times \frac{5}{2} R \times (700 - T)$ ...(i)

Heat obtained by upper compartment = $2\times\frac{7}{2}R\times(T-400)$ ...(ii)

By equating (i) and (ii)

$5(700-T)=7(T-400)$

3000 – 5T = 7T– 2800

6300 = 12 T

T = 525K

$\therefore$ Work done by lower gas = $nR\Delta T$ = – 350 R

Work done by upper gas = $nR\Delta T$ = +250 R

Net work done – 100 R

15. By $A_1V_1 = A_2V_2$

$\Rightarrow \pi(20)^2\times 5=\pi(1)^2V_2 \quad \Rightarrow V_2 = 2\,m/s^2$

16. $\frac{1}{2}\rho_a V_a^2 = \frac{1}{2}\rho_\ell V_\ell^2$

For given V_a

$V_\ell \propto \sqrt{\frac{\rho_a}{\rho_\ell}}$

17. In P, Q, R no horizontal velocity is imparted to falling water, so d remains same.

In S, since its free fall, $a_{eff} = 0$

$\therefore$ Liquid won't fall with respect to lift.

18. **P:** By Q_1 and Q_4, Q_3 and Q_2 F is in +y

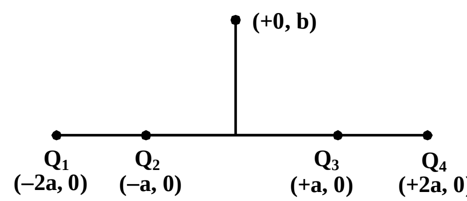
Q: By Q_1 and Q_4, Q_2 and Q_3 F is in +ve x.

R: By Q_1 and Q_4, F is in +ve y

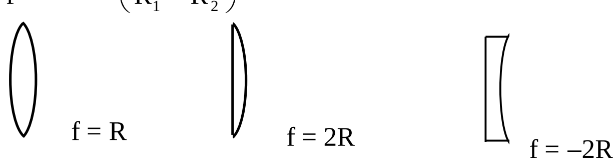
By Q_2 and Q_3, F is in –ve y

But later has more magnitude, since its closer to (0, b). Therefore net force is in – y

S: By Q_1 and Q_4, F is in +ve x and by Q_2 and Q_3, F is in –x, but later is more in magnitude, since its closer to (0, b). Therefore net force is in –ve x.



19. $\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$



Use $\frac{1}{f_{eq}}=\frac{1}{f_1}+\frac{1}{f_2}$

(P) $\frac{1}{f_{eq}}=\frac{1}{R}+\frac{1}{R}=\frac{2}{R};\ f_{eq}=\frac{R}{2}$

(Q) $\frac{1}{f_{eq}}=\frac{1}{2R}+\frac{1}{2R}=\frac{1}{R};\ f_{eq}=R$

(R) $\frac{1}{f_{eq}}=-\frac{1}{2R}-\frac{1}{2R}=-\frac{1}{R}$; f_{eq} = - R

(S) $\frac{1}{f_{eq}}=\frac{1}{R}-\frac{1}{2R}=\frac{1}{2R}$; f_{eq} = 2R

20. Condition for not sliding,

$f_{max} > (m_1 + m_2)\, g \sin\theta$

$\mu N > (m_1 + m_2)\, g \sin\theta$

$0.3\, m_2\, g \cos\theta \geq 30 \sin\theta$

$6 \geq 30 \tan\theta$

$1/5 \geq \tan\theta$

$0.2 \geq \tan\theta$

$\therefore$ for P, Q

$f = (m_1 + m_2)\, g \sin\theta$

For R and S

$F = f_{max} = \mu m_2 g \sin\theta$