Phys 3344:

Introductions:

Zoom

Canvas

Website

References

Schedule:

Today:

Vector Cal review

Units

Projectile motion

Homework #1

Phys 3344 Prof. Olness
Due: 26 Wednesday August 2020 *on Canvas*

Problem 1:

For the unit vectors $\{\hat{x}, \hat{y}, \hat{z}\}$ compute all possible a) dot and b) cross products. (There are 3×3=9 of each.)

Problem 2:

For both $F_1 = x\,\hat{x} + y\,\hat{y}$ and $F_2 = -y\,\hat{x} + x\,\hat{y}$,
a) compute (grad) $\nabla \cdot F$,
b) compute (curl) $\nabla \times F$, and
c) sketch $F_1$and F_2 in the $\{x, y\}$ plane.

Problem 3:

For both $F_1 = r\,\hat{r}$ and $F_2 = \hat{r}/r^2$,
a) sketch $F_1$and F_2 in the $\{r, \phi\}$ plane,
b) compute $\nabla \cdot F$ and $\nabla \times F$ in cylindrical coordinates,
c) compute $\nabla \cdot F$ and $\nabla \times F$ in spherical coordinates.

Problem 4:

a) For $F_1 = r\hat{\theta}$ compute $\nabla \cdot F$ and $\nabla \times F$ in cylindrical coordinates.
b) For $F_2 = r\ \sin\theta\ \hat{\phi}$ compute $\nabla \cdot F$ and $\nabla \times F$ in spherical coordinates.

(Hint: Take a look at the back cover page of the text book.)

Problem 5:

a) A projectile of mass m is launched from a cliff of height h with velocity v at an angle θ above the horizon. Find the a) range of the projectile, b) the time it is in the air, and c) the maximum height above the valley floor.

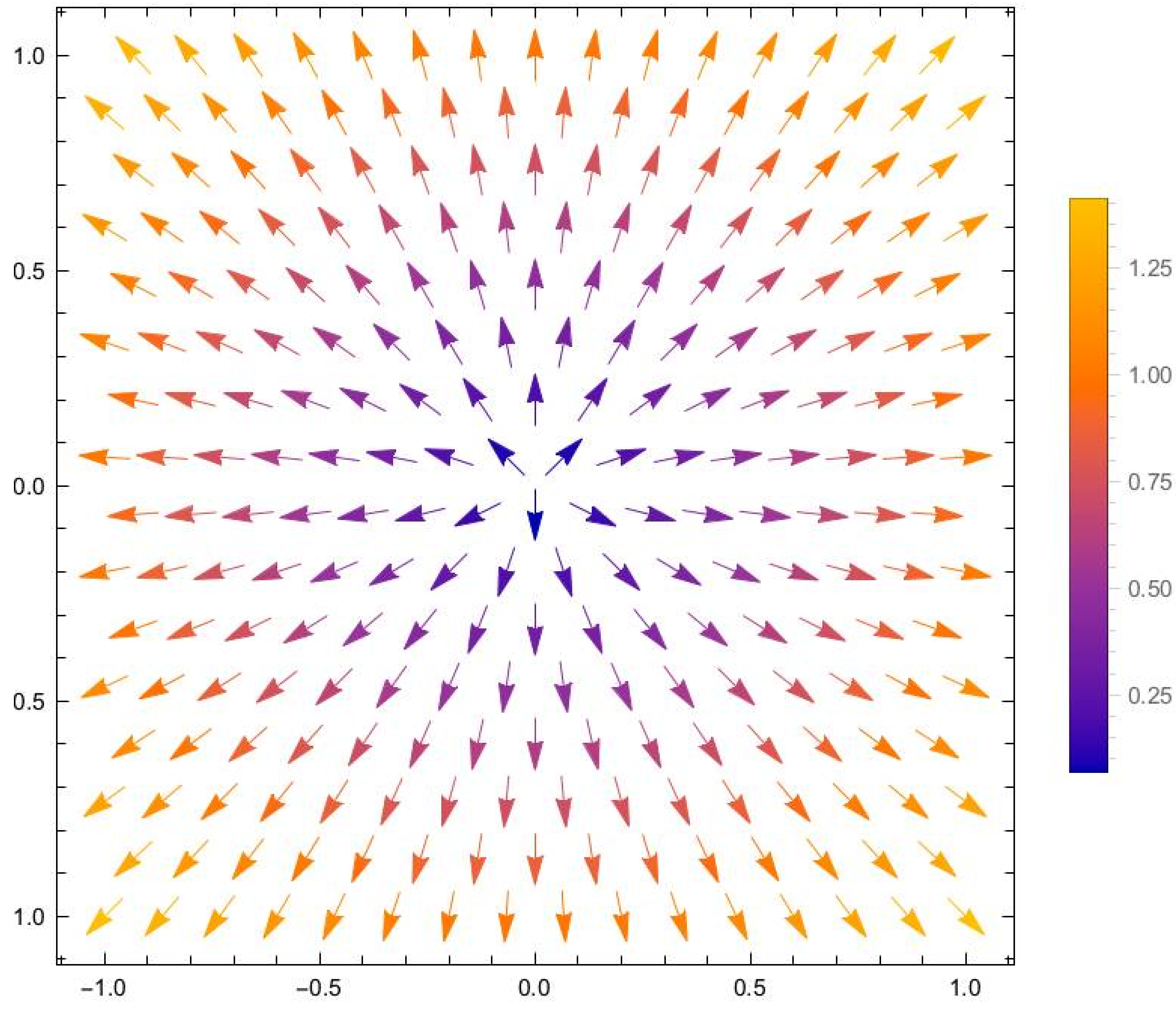
(Hint: This to refresh some of your skills from intro physics.)

Problem 6:

A proton of mass m and charge q circulates in a magnetic field of strength B with velocity v≃c (where c is the speed of light).
a) Find the radius of the orbit.
b) At the LHC B=7.7 Tesla. Compute r in meters. (Look up the values for m, c and q.)

(Hint: Recall the Lorentz force $\boldsymbol{F} = q\,\boldsymbol{v} \times \boldsymbol{B}$.)

	2020 FALL PHYS 3344				
#	DAY	LECTURE:	NOTES:	Chpt	TOPIC
1	TUE	08/25/20	First Class	1	Newtons Laws
2	THUR	08/27/20		2	Projectiles
3	TUE	09/01/20		3	Momentum & Angular Momentum
4	THUR	09/03/20		4	Energy
5	TUE	09/08/20		5	Oscillations
6	THUR	09/10/20			
7	TUE	09/15/20			
8	THUR	09/17/20			**EXAM 1**
9	TUE	09/22/20		6	Calculus of Variations
10	THUR	09/24/20		7	Lagrange's Equation
11	TUE	09/29/20			
12	THUR	10/01/20		8	Two Body Problems
13	TUE	10/06/20			
14	THUR	10/08/20		9	Non-Inertial Frames
	TUE	10/13/20	**Fall Break**		
15	THUR	10/15/20		10	Rotational Motion
16	TUE	10/20/20			**EXAM 2**
17	THUR	10/22/20			
18	TUE	10/27/20		10	Rotational Motion
19	THUR	10/29/20			
20	TUE	11/03/20		11	Coupled Oscillations
21	THUR	11/05/20			
22	TUE	11/10/20		13	Hamiltonian Mechanics
23	THUR	11/12/20			
24	TUE	11/17/20			
25	THUR	11/19/20		14	Collision Theory
26	TUE	11/24/20			
27	THUR	11/26/20	**Thanksgiving**		
28	TUE	12/01/20		15	Special relativity
29	THUR	12/03/20	Last Class		Review
	WED	**Dec 16**	**FINAL EXAM**	**Wednesday Dec. 16,2020, 11:30am - 2:30**	



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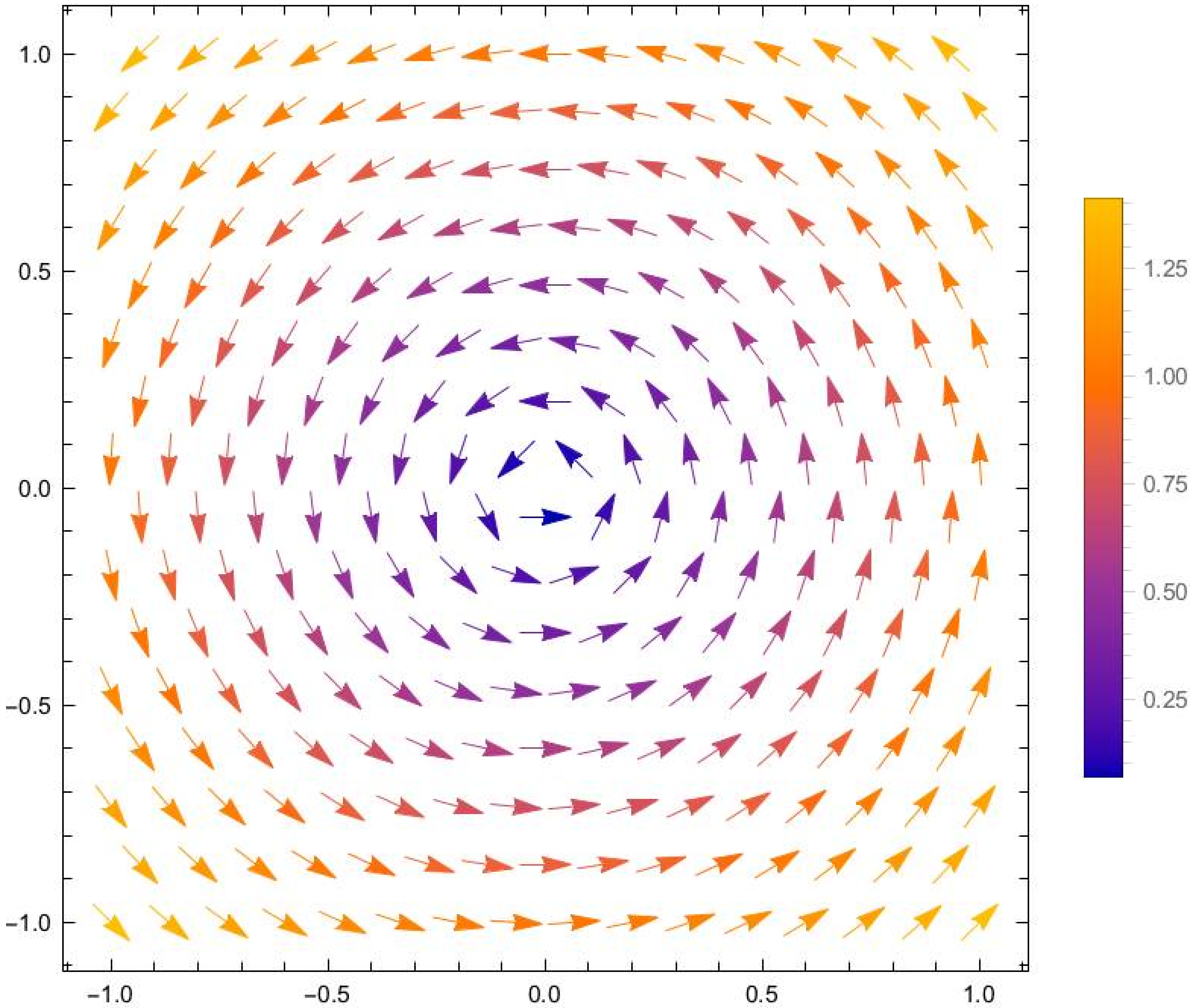
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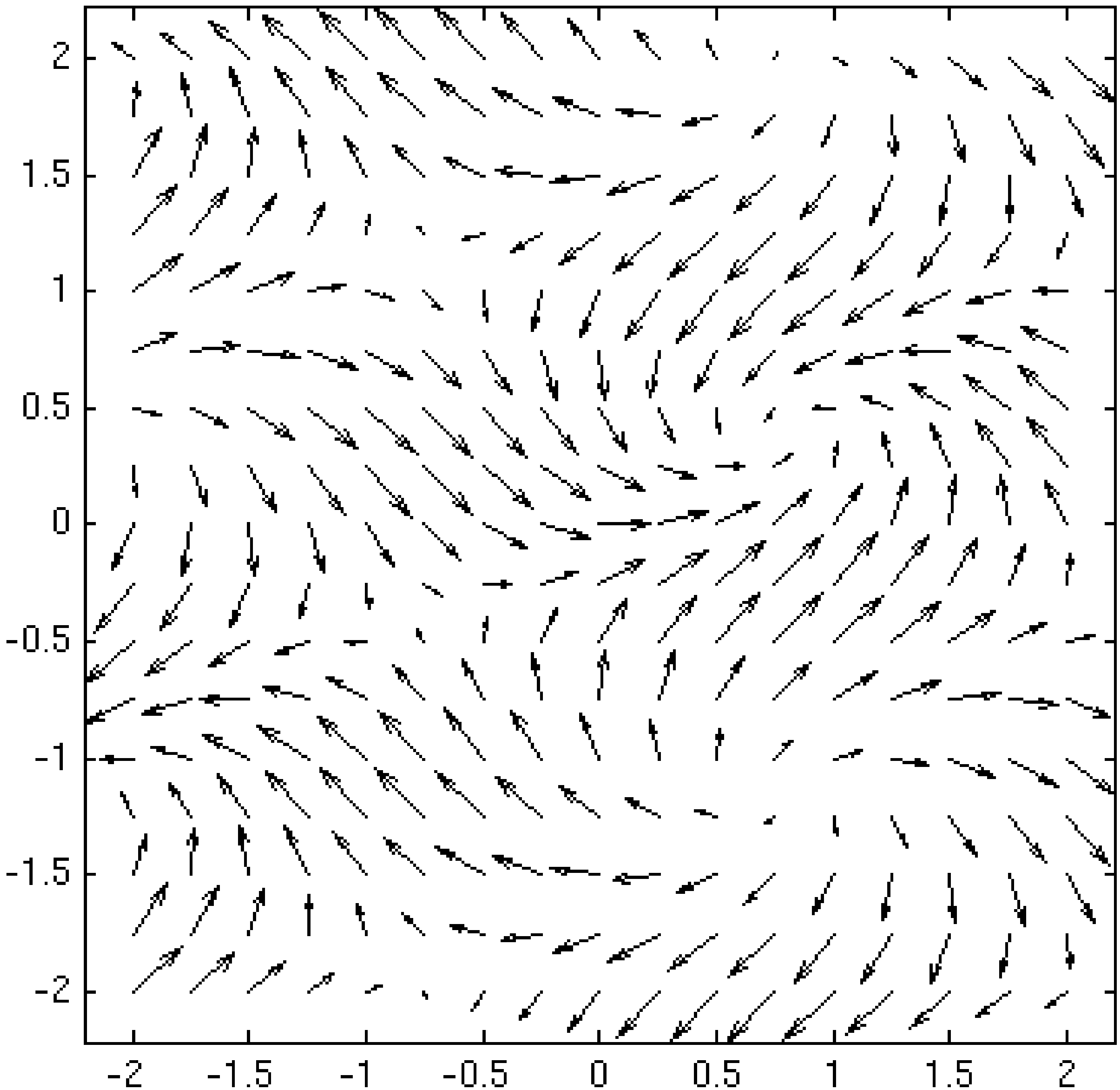

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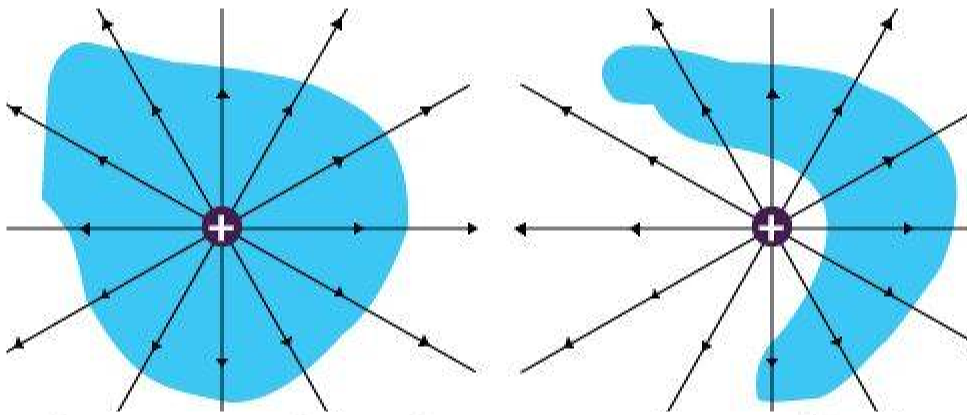
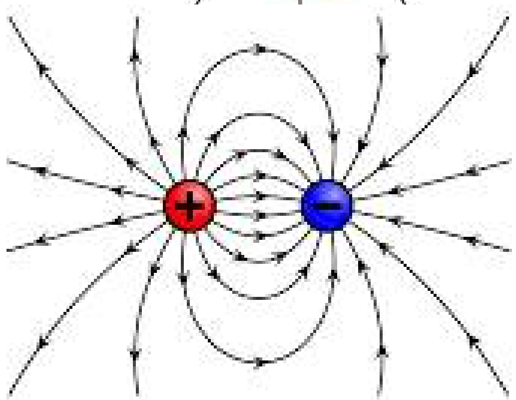
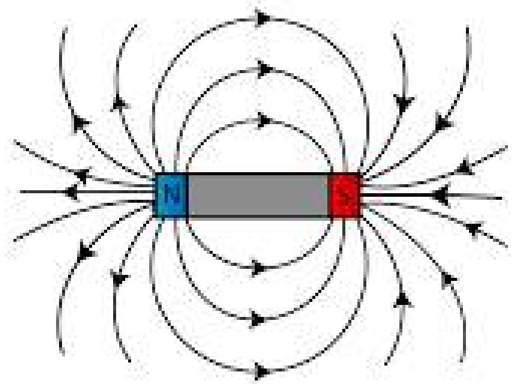
0
-0.5
-1
-1.5
-2
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2

Name	Integral equations	Differential equations
Gauss's law	$\oiint_{\partial\Omega} \mathbf{E}\cdot \mathrm{d}\mathbf{S} = 4\pi \iiint_{\Omega} \rho \, \mathrm{d}V$	$\nabla \cdot \mathbf{E} = 4\pi\rho$
Gauss's law for magnetism	$\oiint_{\partial\Omega} \mathbf{B}\cdot \mathrm{d}\mathbf{S} = 0$	$\nabla \cdot \mathbf{B} = 0$
Maxwell–Faraday equation (Faraday's law of induction)	$\oint_{\partial\Sigma} \mathbf{E}\cdot \mathrm{d}\boldsymbol{\ell} = -\frac{1}{c}\frac{\mathrm{d}}{\mathrm{d}t}\iint_{\Sigma} \mathbf{B}\cdot \mathrm{d}\mathbf{S}$	$\nabla \times \mathbf{E} = -\frac{1}{c}\frac{\partial \mathbf{B}}{\partial t}$
Ampère's circuital law (with Maxwell's addition)	$\oint_{\partial\Sigma} \mathbf{B}\cdot \mathrm{d}\boldsymbol{\ell} = \frac{1}{c}\left(4\pi\iint_{\Sigma} \mathbf{J}\cdot \mathrm{d}\mathbf{S} + \frac{\mathrm{d}}{\mathrm{d}t}\iint_{\Sigma} \mathbf{E}\cdot \mathrm{d}\mathbf{S}\right)$	$\nabla \times \mathbf{B} = \frac{1}{c}\left(4\pi\mathbf{J} + \frac{\partial \mathbf{E}}{\partial t}\right)$







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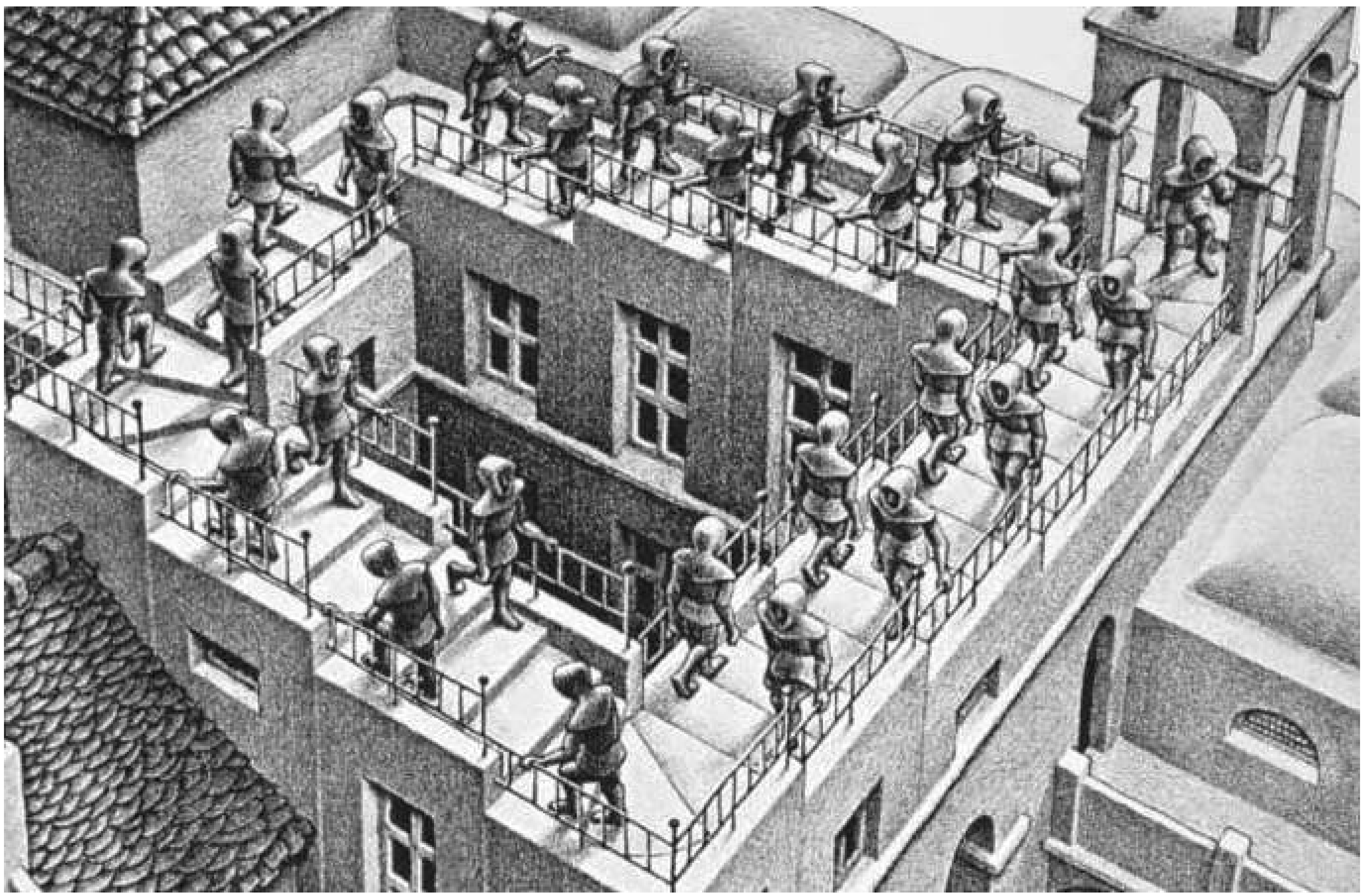
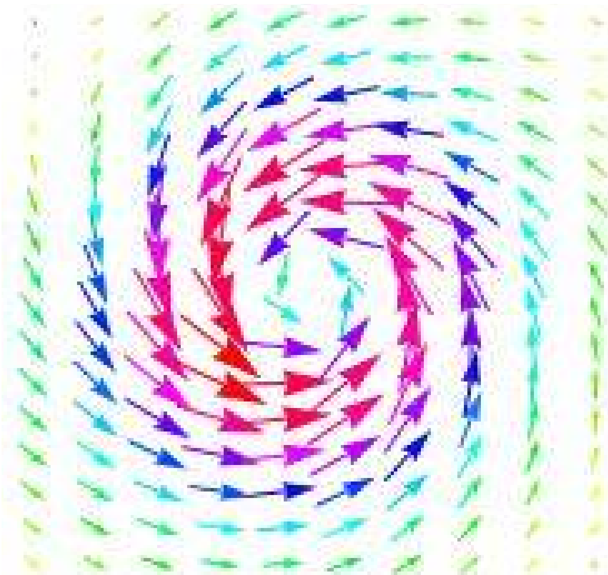




Vector Calculus

$$\nabla f = \hat{\mathbf{x}}\frac{\partial f}{\partial x} + \hat{\mathbf{y}}\frac{\partial f}{\partial y} + \hat{\mathbf{z}}\frac{\partial f}{\partial z} \qquad \text{[Cartesian]}$$

$$= \hat{\mathbf{r}}\frac{\partial f}{\partial r} + \hat{\boldsymbol{\theta}}\frac{1}{r}\frac{\partial f}{\partial \theta} + \hat{\boldsymbol{\phi}}\frac{1}{r\sin\theta}\frac{\partial f}{\partial \phi} \qquad \text{[spherical polars]}$$

$$= \hat{\boldsymbol{\rho}}\frac{\partial f}{\partial \rho} + \hat{\boldsymbol{\phi}}\frac{1}{\rho}\frac{\partial f}{\partial \phi} + \hat{\mathbf{z}}\frac{\partial f}{\partial z} \qquad \text{[cylindrical polars]}$$

$$\nabla \times \mathbf{A} = \hat{\mathbf{x}}\left(\frac{\partial}{\partial y}A_z - \frac{\partial}{\partial z}A_y\right) + \hat{\mathbf{y}}\left(\frac{\partial}{\partial z}A_x - \frac{\partial}{\partial x}A_z\right)$$

$$+ \hat{\mathbf{z}}\left(\frac{\partial}{\partial x}A_y - \frac{\partial}{\partial y}A_x\right) \qquad \text{[Cartesian]}$$

$$= \hat{\mathbf{r}}\frac{1}{r\sin\theta}\left[\frac{\partial}{\partial\theta}(\sin\theta A_\phi) - \frac{\partial}{\partial\phi}A_\theta\right] + \hat{\theta}\left[\frac{1}{r\sin\theta}\frac{\partial}{\partial\phi}A_r - \frac{1}{r}\frac{\partial}{\partial r}(rA_\phi)\right]$$

$$+ \hat{\boldsymbol{\phi}}\frac{1}{r}\left[\frac{\partial}{\partial r}(rA_\theta) - \frac{\partial}{\partial\theta}A_r\right] \qquad \text{[spherical polar]}$$

$$= \hat{\rho}\left[\frac{1}{\rho}\frac{\partial}{\partial\phi}A_z - \frac{\partial}{\partial z}A_\phi\right] + \hat{\boldsymbol{\phi}}\left[\frac{\partial}{\partial z}A_\rho - \frac{\partial}{\partial\rho}A_z\right]$$

$$+ \hat{\mathbf{z}}\frac{1}{\rho}\left[\frac{\partial}{\partial\rho}(\rho A_\phi) - \frac{\partial}{\partial\phi}A_\rho\right] \qquad \text{[cylindrical polar]}$$

$$\nabla \cdot \mathbf{A} = \frac{\partial}{\partial x}A_x + \frac{\partial}{\partial y}A_y + \frac{\partial}{\partial z}A_z \qquad \text{[Cartesian]}$$

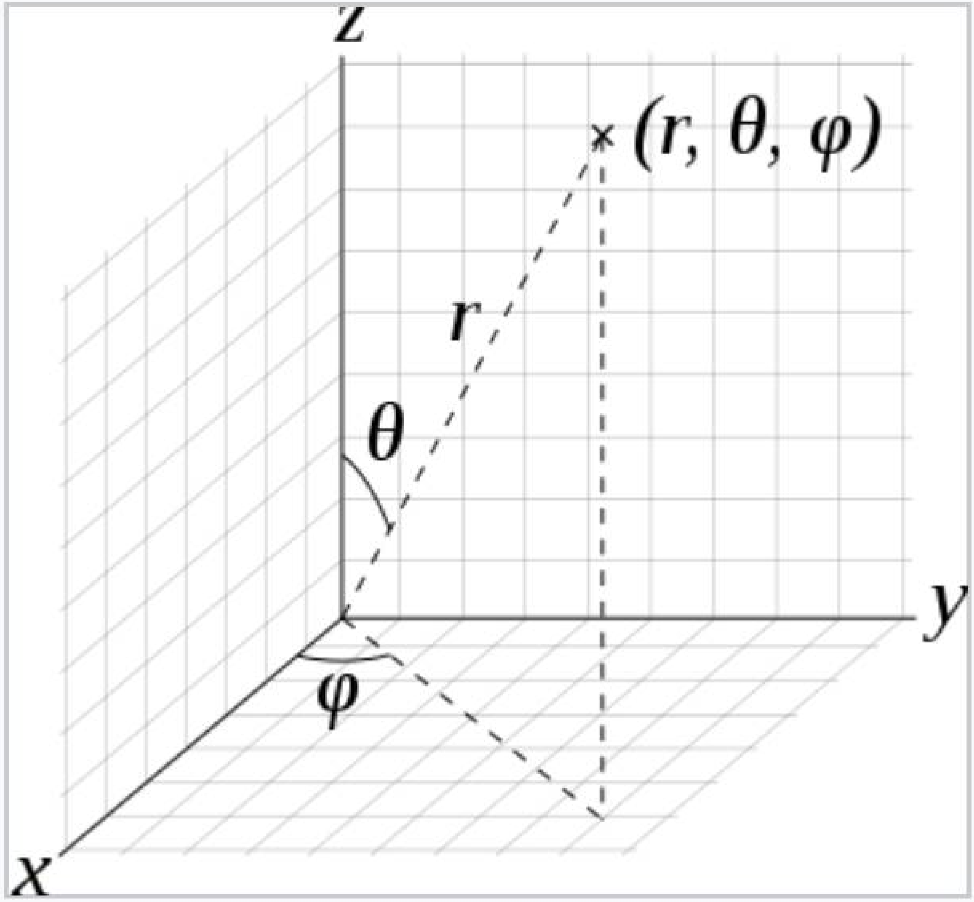
$$= \frac{1}{r^2}\frac{\partial}{\partial r}(r^2A_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta A_\theta) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\phi}A_\phi \qquad \text{[spherical polars]}$$

$$= \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho A_\rho) + \frac{1}{\rho}\frac{\partial}{\partial\phi}A_\phi + \frac{\partial}{\partial z}A_z \qquad \text{[cylindrical polars]}$$

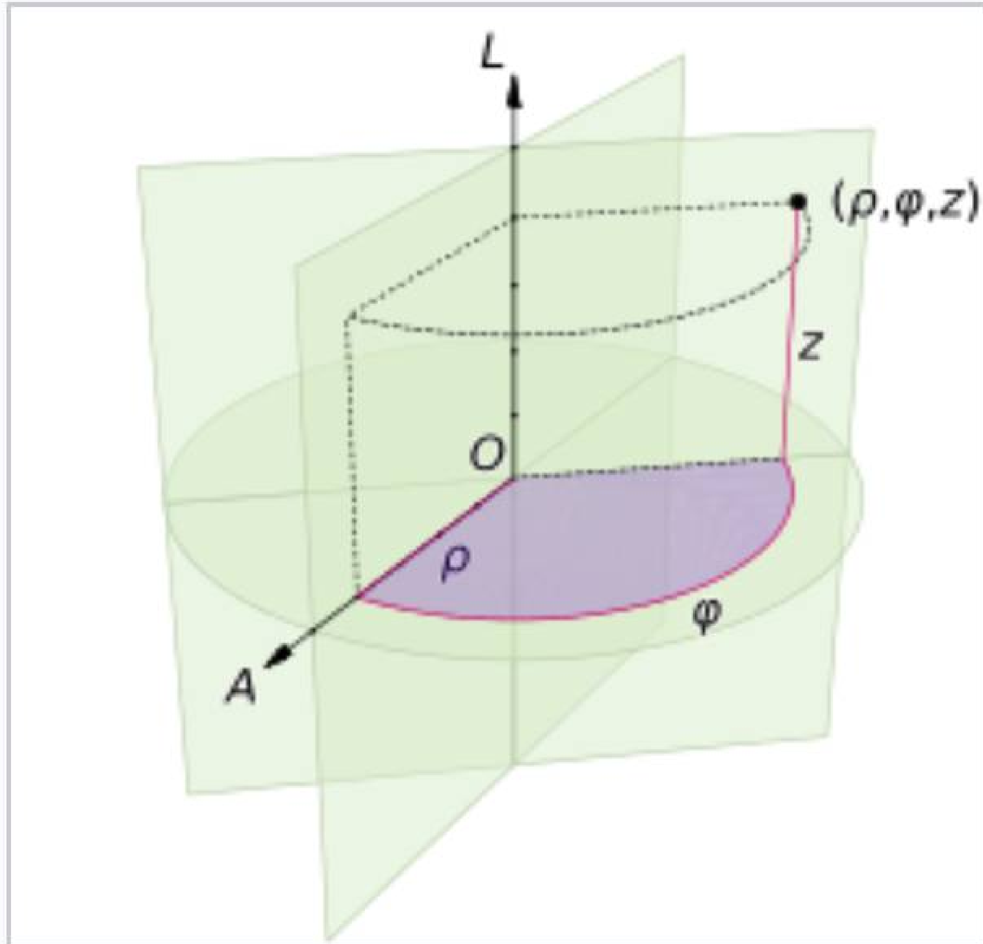
$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2} \qquad \text{[Cartesian]}$$

$$= \frac{1}{r}\frac{\partial^2}{\partial r^2}(rf) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial f}{\partial\theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 f}{\partial\phi^2} \qquad \text{[spherical polars]}$$

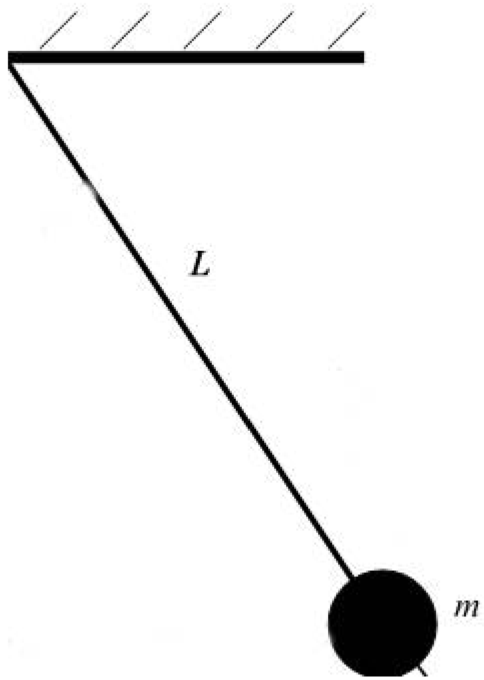
$$= \frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\rho\frac{\partial f}{\partial\rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 f}{\partial\phi^2} + \frac{\partial^2 f}{\partial z^2} \qquad \text{[cylindrical polars]}$$



Spherical coordinates (r, θ, φ) as commonly used in ***physics*** (ISO 80000-2:2019 convention): radial distance r, polar angle θ (theta), and azimuthal angle φ (phi). The symbol ρ (rho) is often used instead of r.

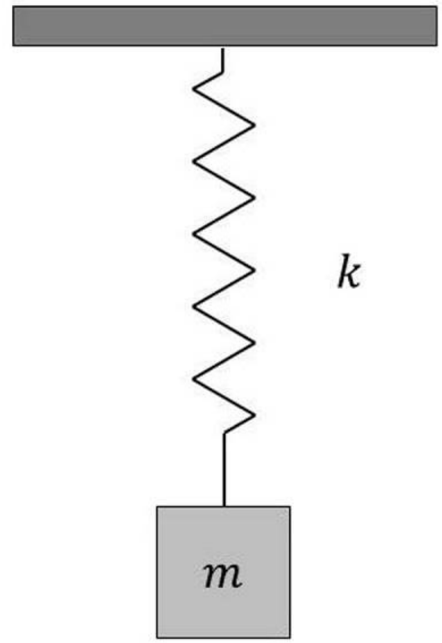


A cylindrical coordinate system with origin O, polar axis A, and longitudinal axis L. The dot is the point with radial distance $\rho = 4$, angular coordinate $\varphi = 130°$, and height $z = 4$.



L, m, g

T= seconds

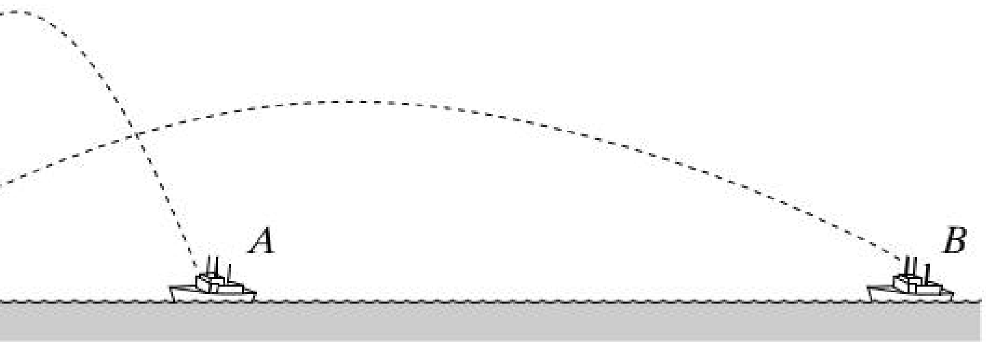


K, m, A,

F= - K x
F= m a

T= seconds

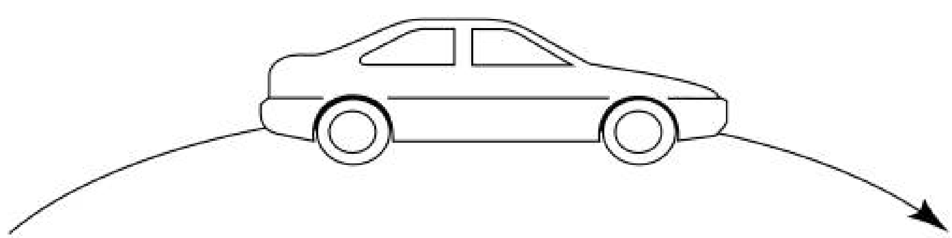
imultaneously fires two shells
s. If the shells follow the par-
ries shown, which ship gets hit



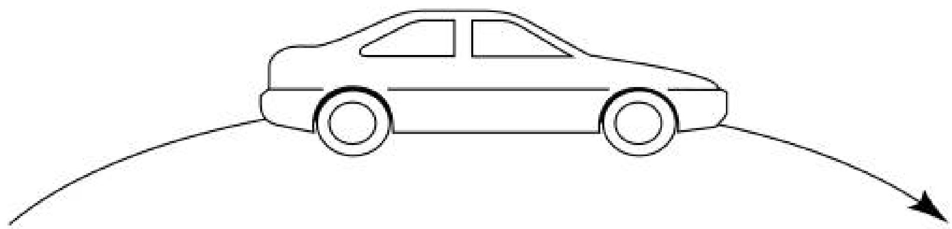
same time

information

A car rounds a curve while mainta
constant speed. Is there a net force
car as it rounds the curve?



A car rounds a curve while maintaining a constant speed. Is there a net force on the car as it rounds the curve?



1. No—its speed is constant.
2. Yes.
3. It depends on the sharpness of the curve and the speed of the car.